Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 801

Contribution from the Bureau of Markets
GEORGE LIVINGSTON, Acting Chief

Washington, D. C. PROFESSIONAL PAPER December 15, 1919

CONSTRUCTION AND FIRE PROTECTION OF COTTON WAREHOUSES

By

J. M. WORKMAN

CONTENTS

	Page
Primary Factors in Warehouse Design	1
Fire-Resistive Construction	16
Slow-Burning Construction	41
Semi-Slow-Burning Construction	50
Frame Construction	57
Iron-Clad Construction	57
Auxiliary Structures	58
Fire-Protective Equipment	61
Precautions Against Fire	75
Selection of Warehouse Design	76
Appendix. Standard Warehouse Plans	79

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 801

Contribution from the Bureau of Markets
GEORGE LIVINGSTON, Acting Chief

Washington, D. C. PROFESSIONAL PAPER December 15, 1919

CONSTRUCTION AND FIRE PROTECTION OF COTTON WAREHOUSES.[1]

By J. M. WORKMAN.

CONTENTS.

Page.
Primary factors in warehouse design ... 1
Fire-resistive construction ... 16
Slow-burning construction ... 41
Semi-slow-burning construction ... 50
Frame construction ... 57
Iron-clad construction ... 57
Auxiliary structures ... 58
Fire protective equipment ... 61
Precautions against fire ... 75
Selection of warehouse design ... 76
Appendix. Standard warehouse plans ... 79

PRIMARY FACTORS IN WAREHOUSE DESIGN.

The construction and fire protection of warehouses for cotton has suffered much from the apparent simplicity of the subject. The majority of cotton warehouses do not combine the essentials for real economy of construction and fire protection with advantageous insurance rates largely because of inefficient planning. The design and construction of the cotton warehouse should be handled by a competent engineer having a thorough understanding of construction, fire protection, insurance requirements and rates, together with some knowledge of warehouse management.

---

[1] Definite suggestions in regard to construction of buildings and fire protection based on desirable principles and practice are presented in this bulletin. Very detailed information, of interest chiefly to the designer of warehouses, is printed in small type as footnotes.

These recommendations as to construction are in general harmony with the Building Code recommended by the National Board of Fire Underwriters. Acknowledgment is made of valuable assistance rendered by Prof. Ira H. Woolson, in the preparation of this discussion.

The success of the cotton warehousing business is strongly influenced by the elements of cost of construction on the one hand, and insurance rates on the other, for these two factors determine very largely the returns on the investment. Primary factors determining warehouse design are the character and volume of the business contemplated, the site for the plant, and the possible arrangement of the buildings.

Certain conditions vitally affect the adoption of both site and arrangement of the plant. Some of these conditions are whether cotton is handled primarily for producers or dealers, with the consequent influence on "turn overs" and "peak loads," whether it is deposited and withdrawn in large or small lots, is generally for shipment to local or to distant points, is stored flat or compressed, is subject to favorable shipping rates. It is apparent that warehouses for local storage, for use as a concentration or compress point, for an export plant, or for a cotton mill warehouse, will present separate problems both from the standpoint of the actual plant and of the handling system and storage methods employed. The solution of these problems is a matter of managerial policy and does not lie within the scope of this discussion.[1]

The site for the plant should be considered with reference to transportation facilities, area available, topography of the ground, character of the soil, and the water supply which is available or can be provided. Transportation connections by both water and rail are desirable, while for the plant handling cotton in large quantities for distant delivery, as at concentration points, such connections may be indispensable. The area available may limit the distribution of the buildings and consequently the design. The toporgaphy of the ground influences both arrangement and design, while the character of the soil sometimes affects the cost of construction with a resulting influence on economy of design. As a rule, no warehouse should be built unless it can be provided with a sufficient water supply for reasonable fire service.

The layout of the plant, or the arrangement of the buildings, should be influenced primarily by the elements of fire hazard, convenience for handling cotton, and the design of the building desired considered with the economical type of construction. Protection against fire exposure demands isolation of buildings and restriction in size of units. At the same time, the arrangement should be such as affords the greatest economy in handling the cotton, which preferably should be moved into the warehouse from one side and turned out from the opposite side. The design of buildings with reference to size and proportion of compartments, story height, and number of stories should be based upon all of the foregoing facts considered in conjunction with the relative cost of various types of construction and the resulting rate of insurance.

---

[1] Newton, Roy L., and Workman, J. M. Cotton Warehousing—Benefits of an Adequate System. In Yearbook of the U. S. Department of Agriculture, 1918.

SOME TYPICAL WAREHOUSE PLANTS.

The selection of the type of construction and design of the buildings used is a matter for the decision of the management, as it is not possible to state that any one type of construction and design is best regardless of the conditions to be met.

A single-story warehouse of semi-slow-burning construction—that is having a heavy timber roof, light frame exterior walls, and brick division fire walls—is shown in Plate I. This plant is well removed from exterior fire hazards so that the construction used is safe and economical. It is used for storing cotton for large producers and the uncompressed bales are tiered five high during the time deposits are heaviest. A story height of 16 feet is used and the building has five compartments with a combined capacity of 5,000 bales of uncompressed cotton.

A large export plant, also of semi-slow-burning construction, is shown in Plate II. Here the buildings are 100 feet wide and are cut into compartments by division fire walls spaced at intervals of 50, 75 or 100 feet. The buildings are arranged in pairs with receiving or delivery courts 100 feet wide between, to provide the necessary isolation and give space for operations of firemen if need arise. Plate III, figure 1 shows a court used for receiving cotton from cars; there is also shown the depressed tracks and the hose houses. In alternate courts the central area is paved and the tracks are omitted. Here the cotton leaving the warehouse for the compress or for shipment by water is handled on low flat trucks drawn by electric storage battery tractors.

In this plant reliance for protection in case of fire is placed in the system of yard hydrants, a complete automatic sprinkler system with ample sources of water supply, and an adequate watchman service.

Plants in which the buildings present exposures to each other, or plants subjected to dangerous exterior exposures (including a passing locomotive) should not depend entirely on fire-protective equipment, but should offer in themselves a strong resistance to fire. It must be remembered that congested handling of cotton in courts between warehouses causes such buildings to present a hazard to each other that may be very serious. An inexpensive method of securing protection from such exposures is to use masonry for the exposed walls and frame construction for the walls not exposed. In the case of a number of parallel buildings with courts between only one exterior side wall of each entire building may be masonry. Such an arrangement is good but is not nearly so satisfactory as when all walls are masonry.

Slow-burning construction is illustrated by the photograph of a warehouse of three-story design in Plate III, figure 2. This building has floors and roof of timbers and heavy planking, exterior and division walls of brick, with tin-clad fire doors throughout. The platform is of reinforced concrete which requires practically no repairs and does not communicate fire. In this building the story height is only 8½ feet and cotton is stored one bale high on end. Such buildings should not exceed three stories in height unless there are floors of reinforced concrete to serve as fire breaks. The type of exterior door used in this building is shown by Plate XIII, figure 2.

A similar building, well suited to conditions which demand concentration or where the area is limited, is shown in Plate IV, figure 1. For buildings of this design it is best that all floors be fire-resistive. The fire-resistive floor has the advantage of limiting the amount of cotton subject to a single fire and, what is more important, it serves as a tie to the walls and prevents their subjection to such severe and prolonged heat as to cause their failure from expansion. For such buildings the automatic sprinkler equipment is practically essential, while the installation of stand-pipes with hose equipment on each platform is of great importance. A view of such a standpipe and hose equipment is shown in Plate XXXII. It usually is not necessary to have platforms on both sides of the building, but if platforms are omitted on one side, doors of sufficient number and size should be provided on that side to permit of cotton being thrown out and, more important, to admit of ready access by firemen. These features of construction are illustrated by Plate IV, figure 2. In this view the minimum number of doors advisable is shown. If any floors in the building are fire resistive, or if the exterior exposure is hazardous, doors should be covered with tin as described for fire doors under "Fire-resistive construction," or should be otherwise equivalent to fire doors. The iron ladder gives ready access to the doors.

Fire-resistive construction for the warehouse does not involve any radical departure in design from the slow-burning construction described. The difference is that all floors and roof are of fire-resistive material, such as reinforced concrete, and that openings are fully protected as required by their location and exposure. The construction of the floors and other features are discussed under "Fire-resistive construction." An interior view of such a building showing the arrangement of the automatic sprinkler heads and method of storing is shown in Plate XVI, figure 1, and the exterior of such a building is shown in Plate XVII, figure 1.

COTTON HANDLING EQUIPMENT.

Inasmuch as the design of building adopted is related to the handling equipment employed, this equipment should be provided for at the time of construction.

For the majority of warehouses the two-wheel truck is in general use. These may be had constructed entirely of steel.

Large plants are using the electric storage battery truck or tractor and trailers to a considerable extent. The latter arrangement is quite satisfactory for cotton handling. A photograph of such a tractor and a train of cars loaded with cotton is shown in Plate V. The low trailer cars are easily loaded without lifting the cotton. They are arranged to follow the tractor accurately, so that a train of several cars is carried readily through doors and around corners. These tractors may be operated inside the storage compartment without danger of fire. There are several makes of tractors on the market, some being driven and steered by all four wheels, others being driven by two wheels and steered by two, while still another type has but three wheels, using two as drivers and one as a steering wheel. Batteries are charged at night and operated all day.

Several large warehouses use an overhead trolley system such as is shown in Plate VI. While this system is developed well for these particular plants, it is not recommended for the average warehouse.

In the warehouse of several stories elevating equipment usually is needed in addition to trucks. Two-story warehouses occasionally can be arranged so that cotton is received on the level of the upper floor, 4 feet above the driveway or railway siding. The bales may then be trucked down an inclined platform or sent down a sliding chute, such as is shown at about the center of the platform of the warehouse illustrated in Plate III, figure 2. In such case it is necessary to provide a railway siding depressed sufficiently to bring the car floor to the platform level. Unfortunately, such arrangements seldom can be made economically. There are but few conditions which justify the labor of trucking up an incline. so that elevating equipment usually must be provided.

A development of the incline for elevating cotton placed on the two-wheel truck is shown in Plates VII, figure 1, and Plate VIII. This consists of an incline, preferably of reinforced concrete, containing a slot in which travels an endless sprocket chain having bracket or hook links at intervals. These hooks engage the axle of the truck and pull it up the incline, the truckman holding the handles as shown. The endless chain is driven by an electric motor or other power. The truck is generally brought down an incline which is similar except that the sprocket chain is omitted and the slope is less steep.

The electric hoist is valuable in a warehouse in which cotton is handled rapidly. An illustration of this equipment is shown in Plate VII, figure 2. The machinery is protected in the little house shown on the steel frame. Two motors supply both vertical and lateral movement to the steel hooks carrying the bale. This equipment can be housed under the warehouse roof and controlled from any floor by a cable at the doors. This hoist will handle readily 100 bales an hour from the first to the third or fourth floor, a little more time being required to deliver to higher floors. However, several men are required for the operation of the hoist, as there must be one man to operate the machine, one on the lower floor to hook the bale, and one on the upper floor to release the bale, besides those assigned to trucking the cotton to and from the hoist. The hoisting apparatus may be used also for lowering cotton, although better and more economical results are secured from the use of a bale chute.

The ordinary spiral package chute of sufficient size supplies the best means for lowering cotton. Views of this form of chute are shown in Plate IX, figures 1 and 2. The installation shown is arranged so that the bales are delivered to the bottom floor already headed up and ready for the truck. A straight chute can be constructed of skids, 3 inches wide, and shod with heavy strap iron. The chute may pass through a number of floors and, by the use of trap doors, bales may be delivered from any floor to any other floor below. A bale chute and an electric hoist are shown in the warehouse in Plate III, figure 2.

Where the conditions do not demand rapid elevation of the cotton or where available labor is limited the regular platform elevator is the best hoisting equipment. Such elevators may be operated by a belted mechanical connection, by electric motor, or by direct steam connection. The elevator also may be used for transfer of electric trucks or loaded trailers from one level to another. The arrangement of the building for an elevator used for cotton bales is shown in Plate X. A somewhat different arrangement is desirable if electric trailers are to be handled on the elevator.

In addition to these forms of handling equipment the slatted belt conveyor arranged on an incline and with spiked slats for engaging the bales of cotton is used to some extent.

For piling cotton the machine in most general use is a small portable elevator such as shown in Plate XI. The movable platform is equipped with a series of rollers so that the bale, when elevated to the top of the pile, may be pulled off easily. Another good type of this machine is arranged to revolve upon the castored truck base, which gives great convenience in moving and setting. The machines are constructed for operation by hand and by electricity. The hand machines are necessarily rather slow in operation when elevating a bale of cotton, but the electric machines make possible very rapid piling. When they are equipped with a properly enclosed motor, the machine affords practically no fire hazard, provided the wiring and all connections are properly designed and installed. The cable extending to the machine should be inclosed in a flexible metal conduit and all socket connections should be located on the ceiling. By using a cable with a length equal to the combined height of the story and of the machine and by connecting the cable to the top of the elevator it is possible to move the machine within a circle of considerable area without the cable coming in contact with the floor. In cases where the cable is allowed to lie on the floor and is not inclosed there is introduced a serious fire hazard because of the probable damage to the cable from trucks passing over it.

Scales in general use for weighing cotton are the ordinary beam scale, the portable platform beam scale, and the dial scale, which may be stationary or arranged on castors so that it can be moved from one to another of a series of very shallow pits. This movable dial scale is well adapted to weighing the bale of cotton while on the truck for the platform is large and a "tare beam" is provided for deducting automatically the weight of the truck. A view of such a scale in use is shown in Plate XII. Since this method of weighing requires that trucks be of a uniform weight, those made of steel are particularly desirable. The illustration shows portable inclines on each side of the scale. This arrangement is excellent where the shallow pits can not be provided readily. Such scales are coming into more general use and are beginning to displace the beam scale, which for a long time has been considered standard equipment for the cotton warehouse.

THE WAREHOUSE PLANT AND BUILDINGS.

Local conditions influence the layout of the warehouse to such an extent that the arrangement of buildings should be decided upon after consideration of these factors and with the approval of the insurance rating bureau having supervision of the particular territory involved.[1]

---

[1] Nixon, Robert L. Cotton Warehouse Construction. U. S. Department of Agriculture, Bulletin 277, 1915.

Fundamental requirements for the arrangements of buildings not only demand that they be isolated as much as possible from adjacent property hazards, but that the several buildings should be arranged in such manner as to minimize the exposure, or fire hazard, that they present to each other. This is so important that it should be the first consideration in the design of the plant. Among exterior fire hazards a passing locomotive should not be overlooked.

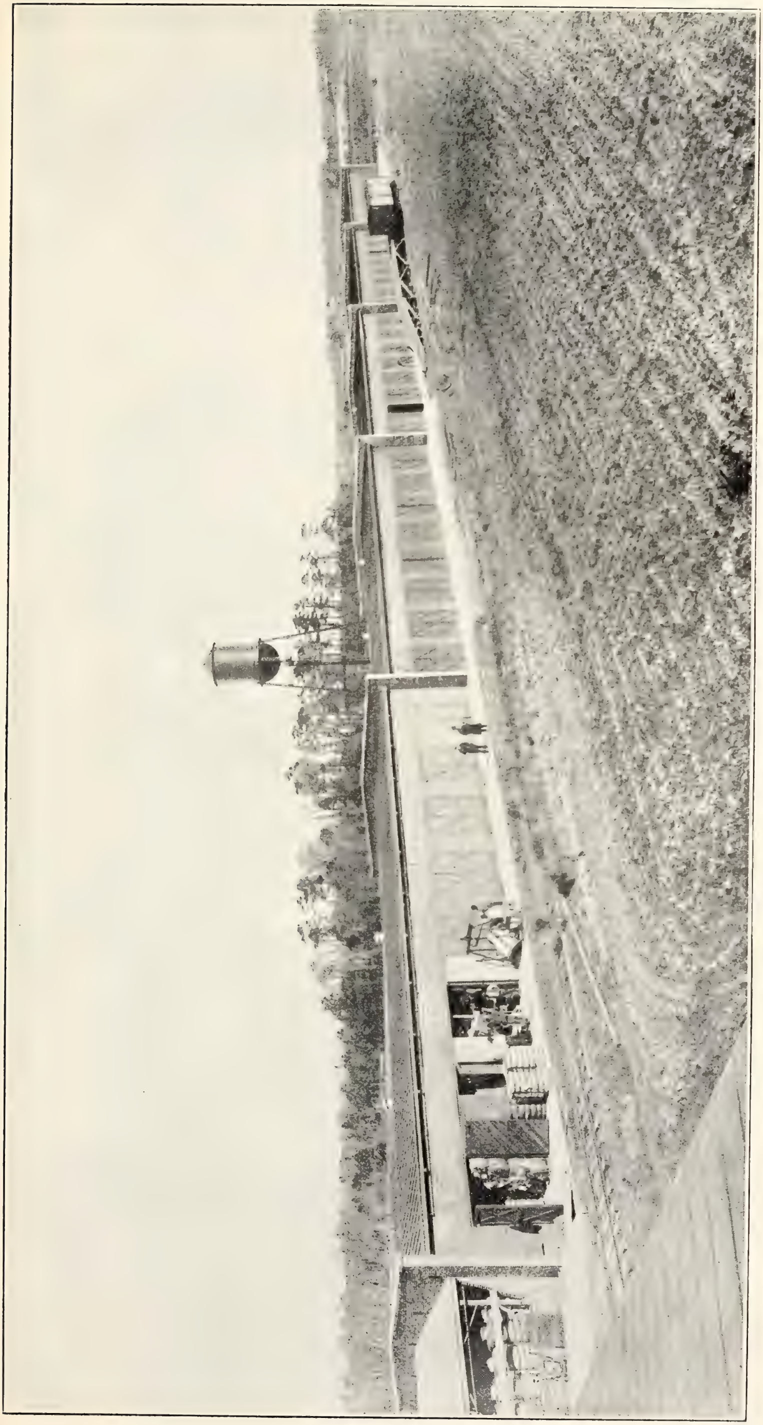
The buildings necessary for a complete warehouse plant vary according to the nature of the business conducted. In addition to the warehouse storage compartments there may be the compress compartment, sheds for receiving and delivering cotton, boiler house, pump house, hose or hydrant houses, office and classing rooms (which may provide a file room for cotton samples), and a watchman's room. Each of these buildings presents definite requirements for construction and fire protection.

The design of the warehouse buildings should be selected with a view to the cost of construction, maintenance and operation on the one hand, and resulting fire hazard and insurance rates on the other. The most important item from both standpoints is the size and proportions of the compartments. After the capacity of the compartment is determined, its proportions must be considered in adopting a particular type of construction. The design of the building as regards the number of stories is usually determined by local conditions, but, all things considered, the single story warehouse is to be preferred in the majority of cases, if cotton can be piled with reasonable convenience. If cotton is not piled, the building of several stories is more economical and convenient.

The warehouse building should be divided into compartments in order to reduce as far as is economically practical the amount of cotton which may be subjected to a single fire. A compartment may be considered as that portion of the building which is cut off from all other parts of the building by fire-resistive division walls, or such walls and fire-resistive floors so combined that a fire will not be communicated readily from one of these sections to another. This reduction of single areas and protection of each against the other is a principle of the greatest importance in cotton warehousing.

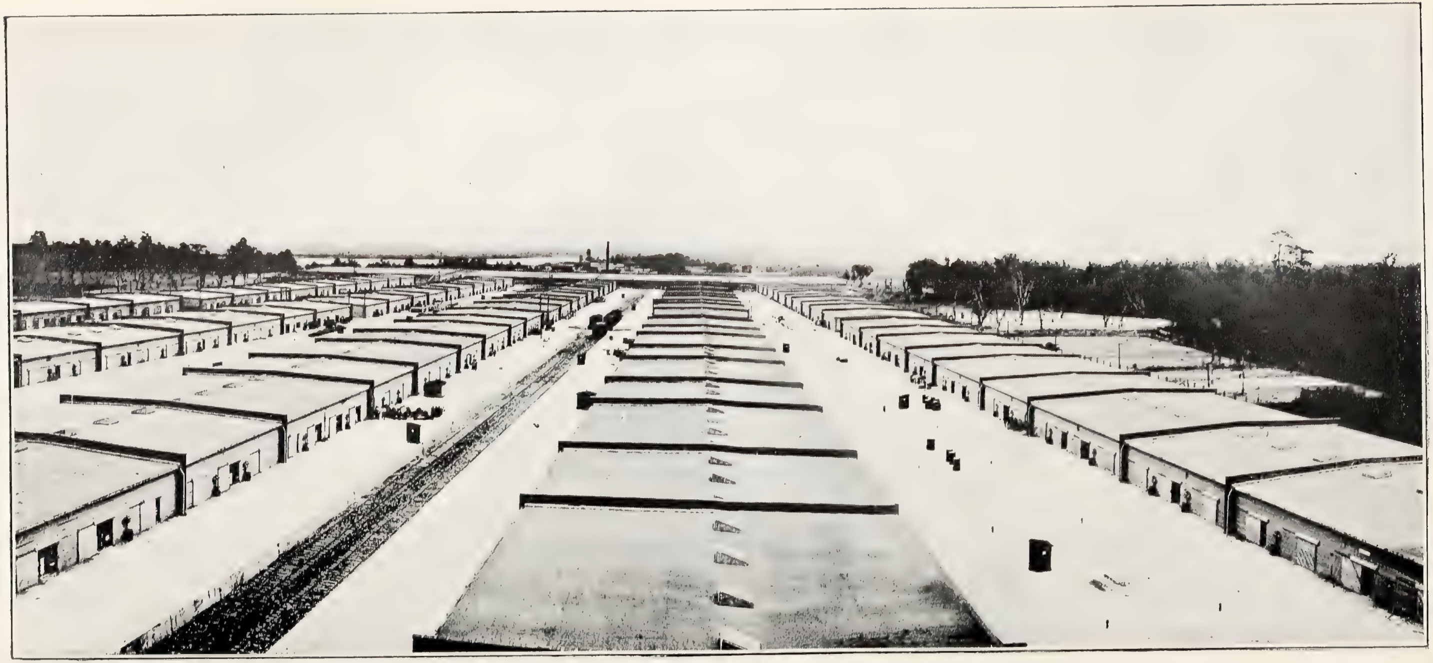
THE COMPARTMENT.

The size of the compartment should be such as to limit the cotton which may be stored therein to an amount of reasonable value. It usually is conceded as desirable that the size of the compartment should not permit the storage of more than 600 bales of cotton, while in few cases should the number of bales exceed 1,000. This view of the capacity of the storage compartment conforms to the usual in-



A SMALL TOWN WAREHOUSE OF 5,000 BALES CAPACITY.

The building is of the semi-slow-burning type of construction, the exterior walls entirely of doors or of doors and light framing weatherboarded.



A CONCENTRATION AND EXPORT PLANT OF SEMI-SLOW-BURNING CONSTRUCTION.

The wide courts are for receiving from cars and for delivery to the compress in the background. The hose houses are located between the buildings.

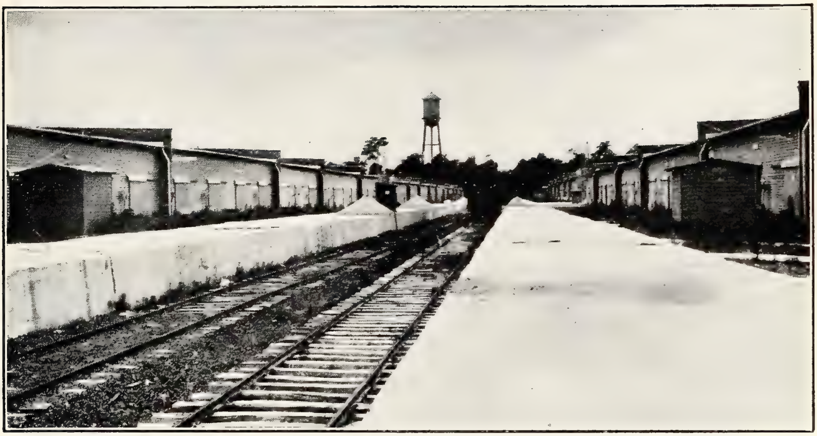


FIG. I.—VIEW OF RECEIVING COURT WITH DEPRESSED TRACK AND PAVED RUNWAYS.

Cotton is handled from the cars and into and out of the warehouse both by the ordinary two-wheel hand truck and by electric tractors.

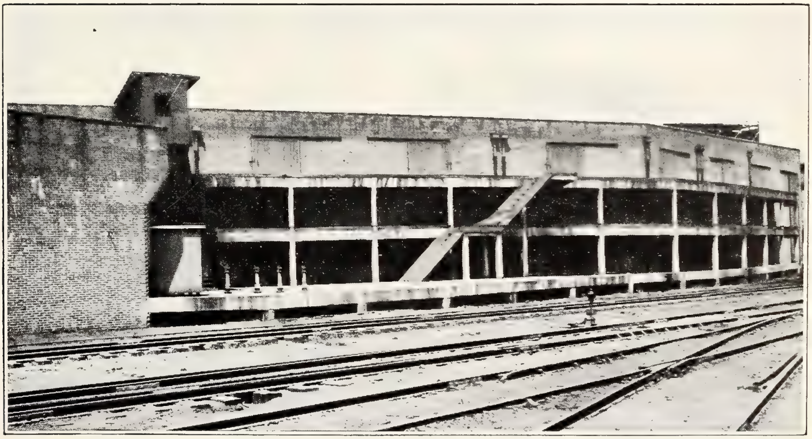


FIG. 2.—AN EXCELLENT WAREHOUSE OF SLOW-BURNING CONSTRUCTION WITH PLATFORM OF REINFORCED CONCRETE AND DOORS TIN COVERED.

Note the electric hoist at the left and bale chute and stair combined at the center.

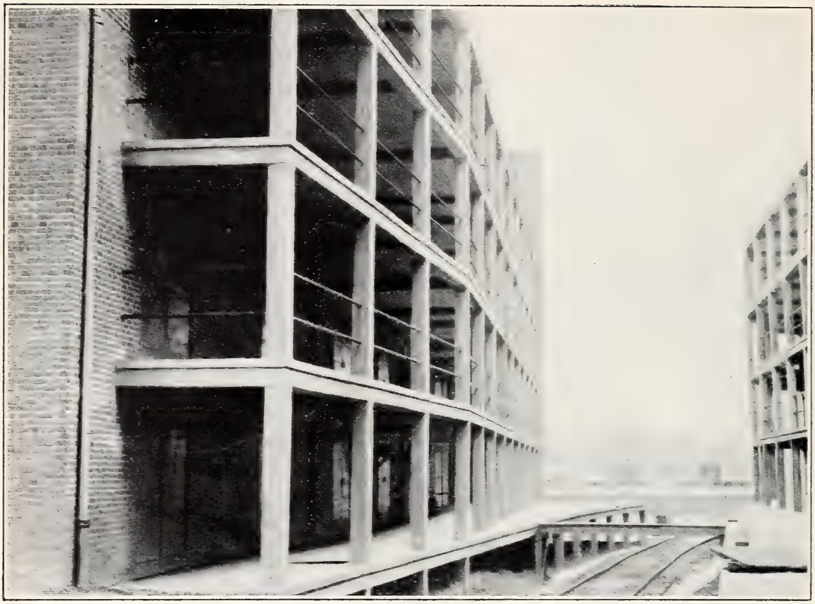


FIG. I.—A WAREHOUSE OF FIRE-RESISTIVE OR SLOW-BURNING CONSTRUCTION WITH PLATFORMS.

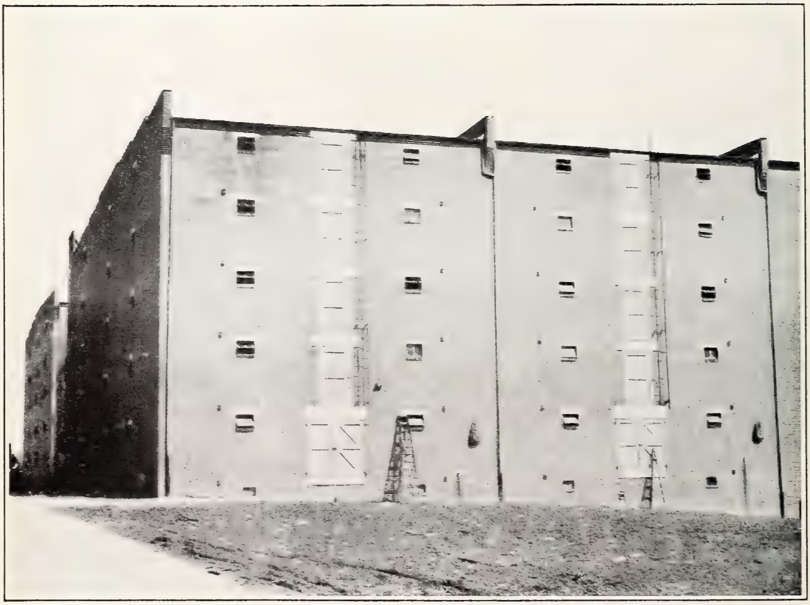
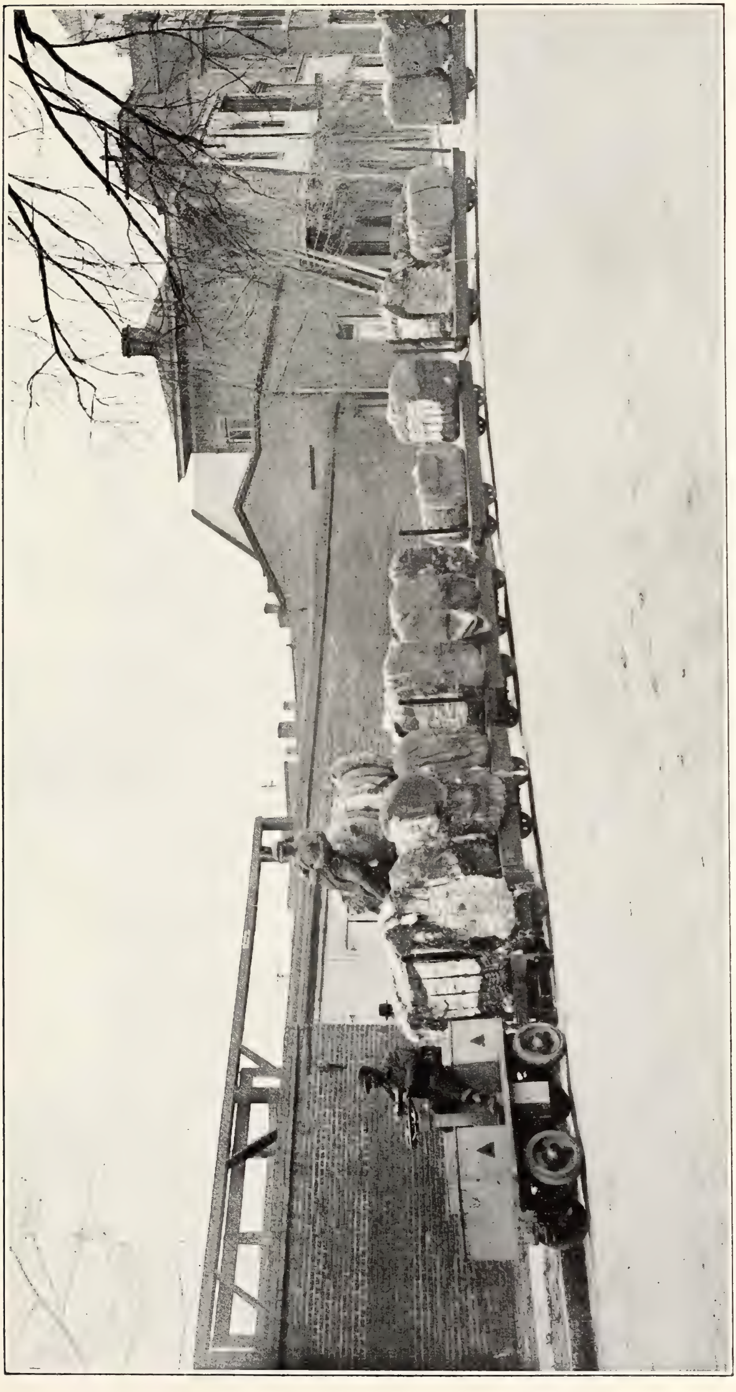
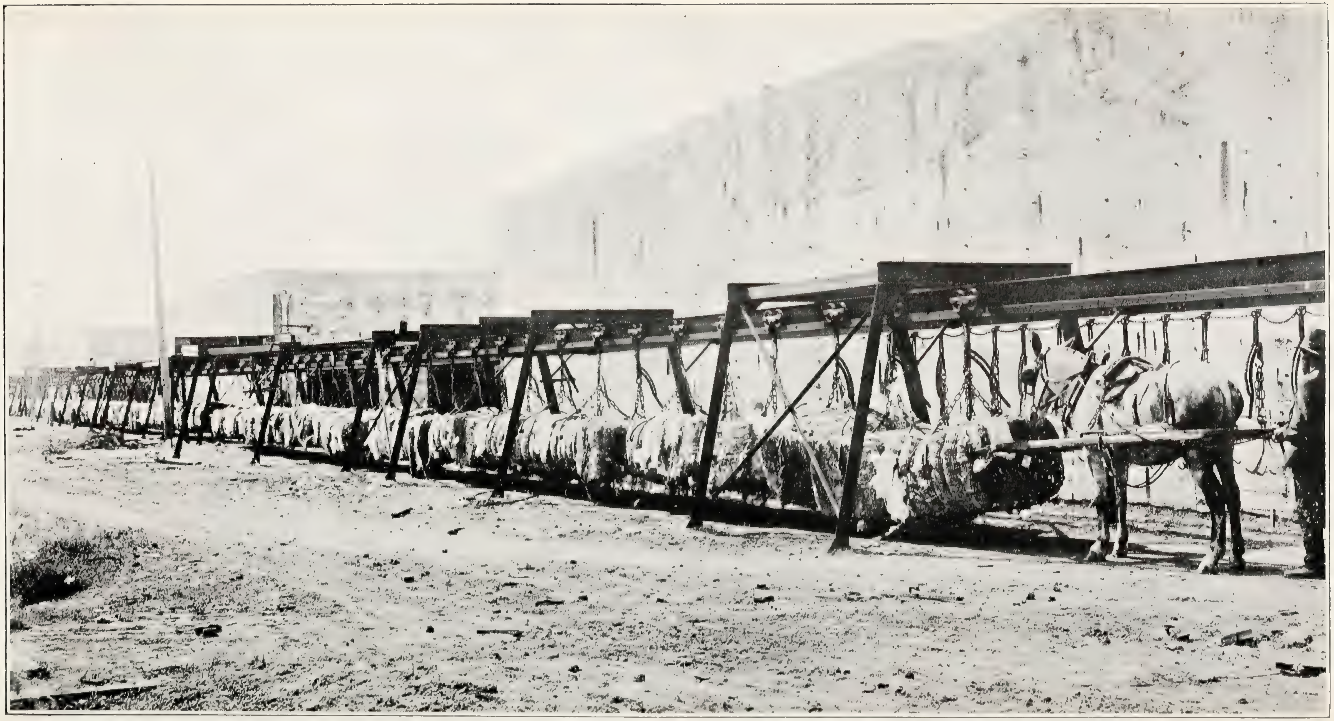


FIG. 2.—A WAREHOUSE WITH DOORS IN REAR WALL FOR USE OF FIREMEN, AND WITH IRON LADDER EXTENDING TO DOORS AND ROOF.



ELECTRIC STORAGE BATTERY TRACTOR DRAWING TRAILER TRUCKS LOADED WITH COTTON.

A variety of such equipment is in use.



AN OVERHEAD TROLLEY SYSTEM SHOWING A LINE OF BALES BEING PUSHED BY A MULE.

When moving down an inclined section of track the mule is not used.

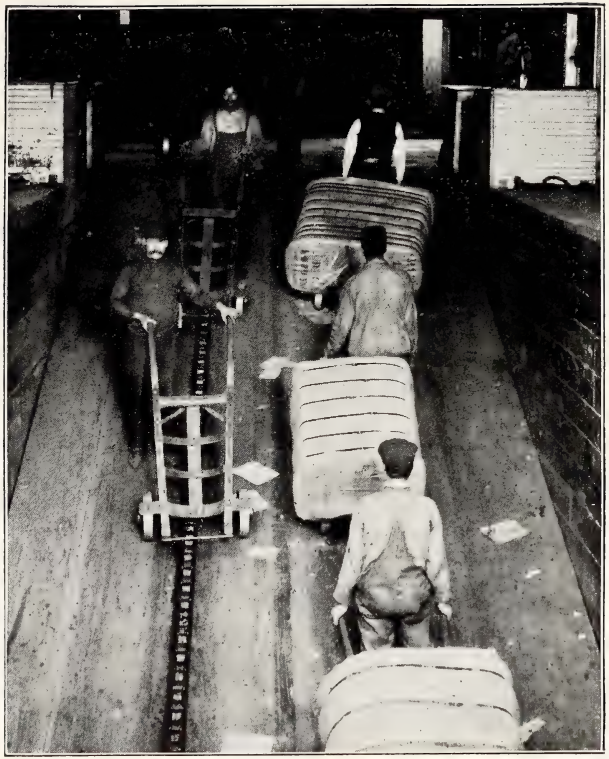


FIG. I.—GENERAL VIEW OF INCLINE CONVEYOR.

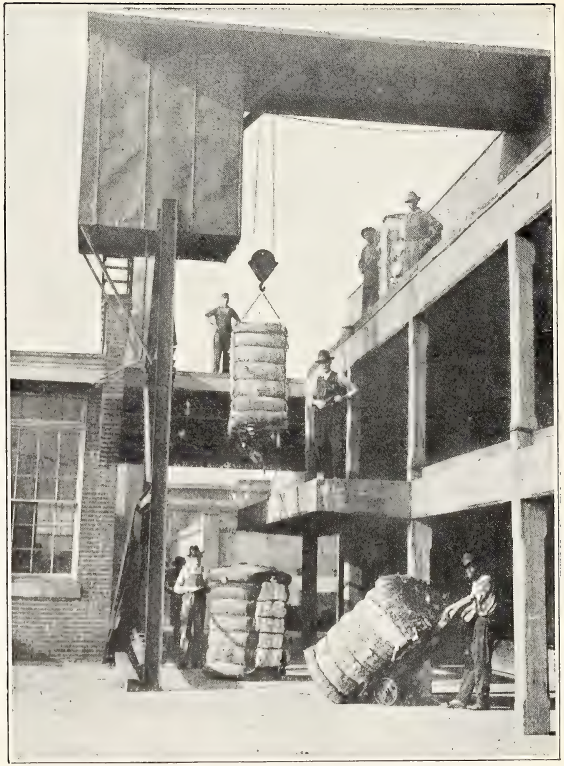
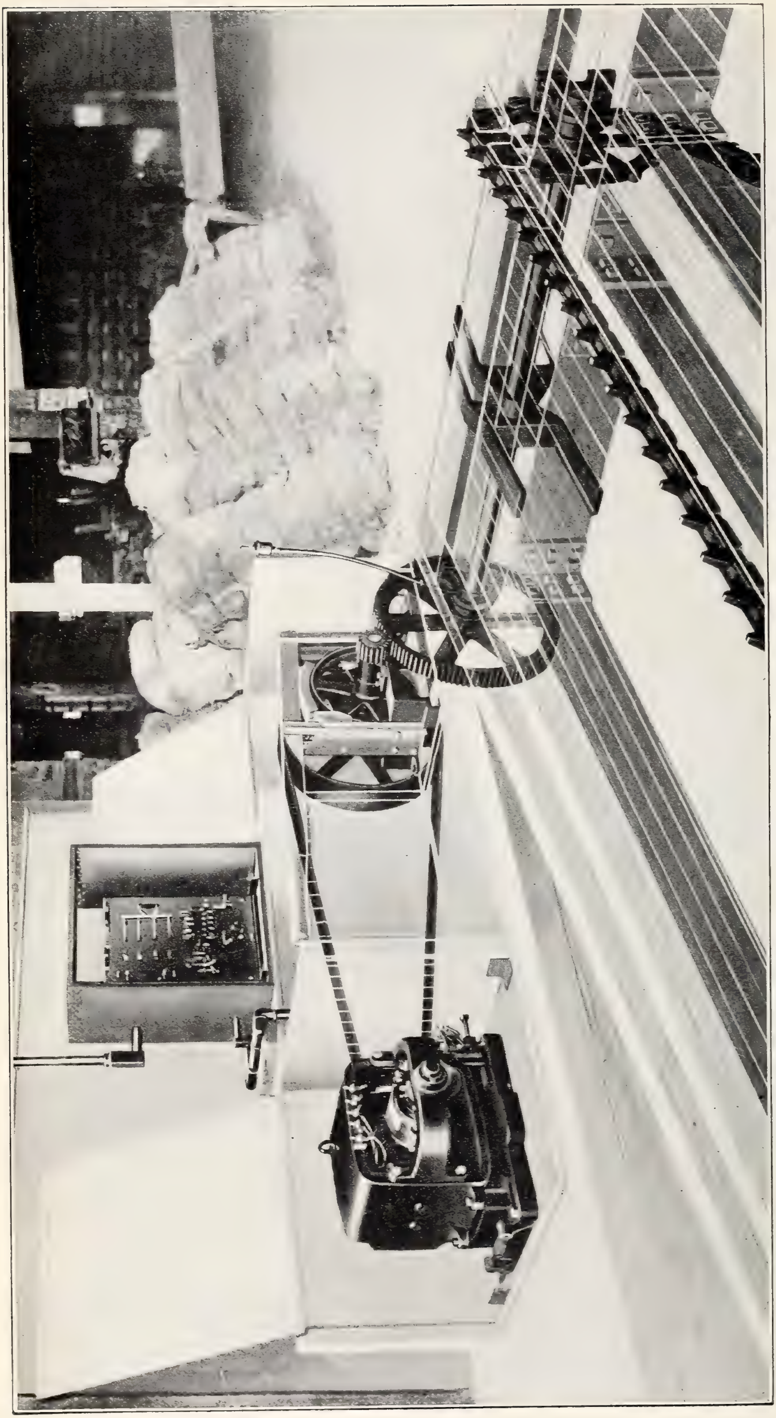


FIG. 2.—OUTSIDE ELECTRIC HOIST IN USE.
This equipment will elevate cotton with great rapidity.



DETAIL VIEW OF INCLINE CONVEYOR SHOWING BRACKET LINKS OF CHAIN.

The chain continues in motion and is always ready for use, though it is readily stopped from either the top or bottom of the incline.

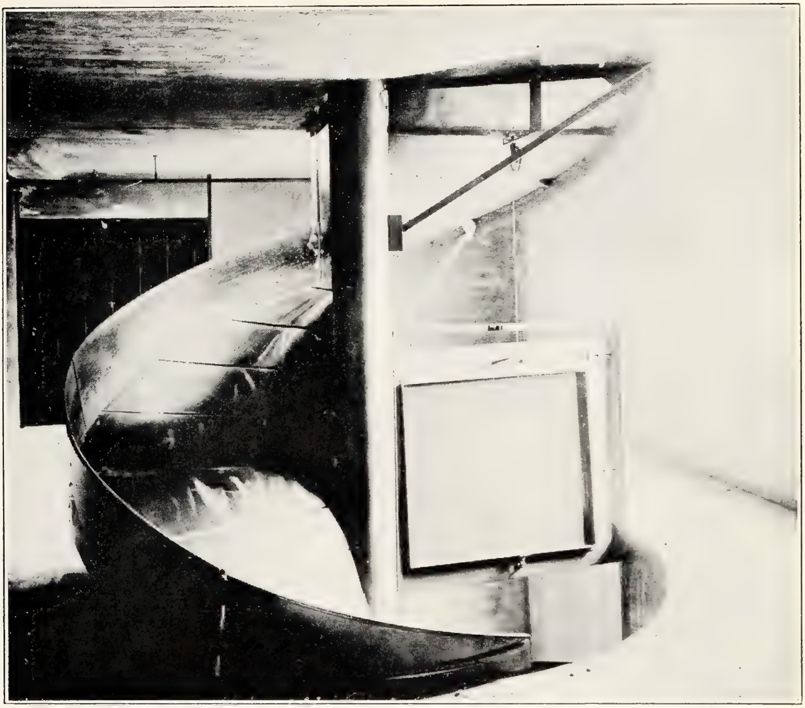


FIG. 1.—SPIRAL CHUTE FOR LOWERING BALES OF COTTON.

Note the fire shutter which is arranged to drop automatically in case of fire. In addition to this precaution chutes should be inclosed by fire walls.

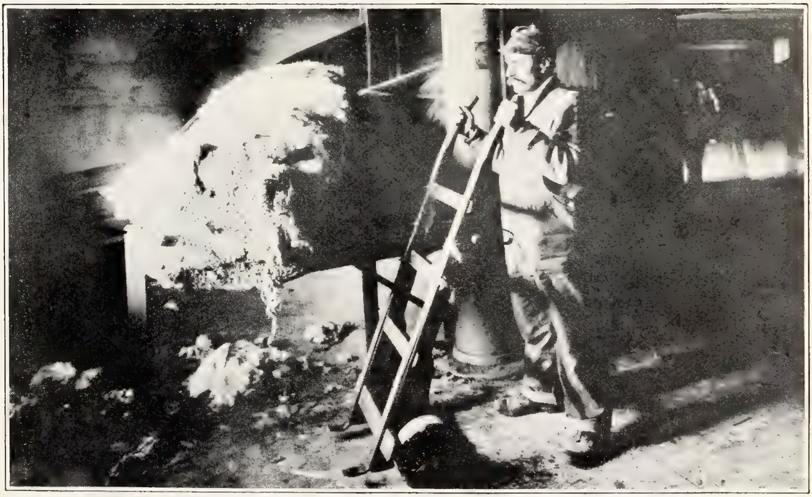
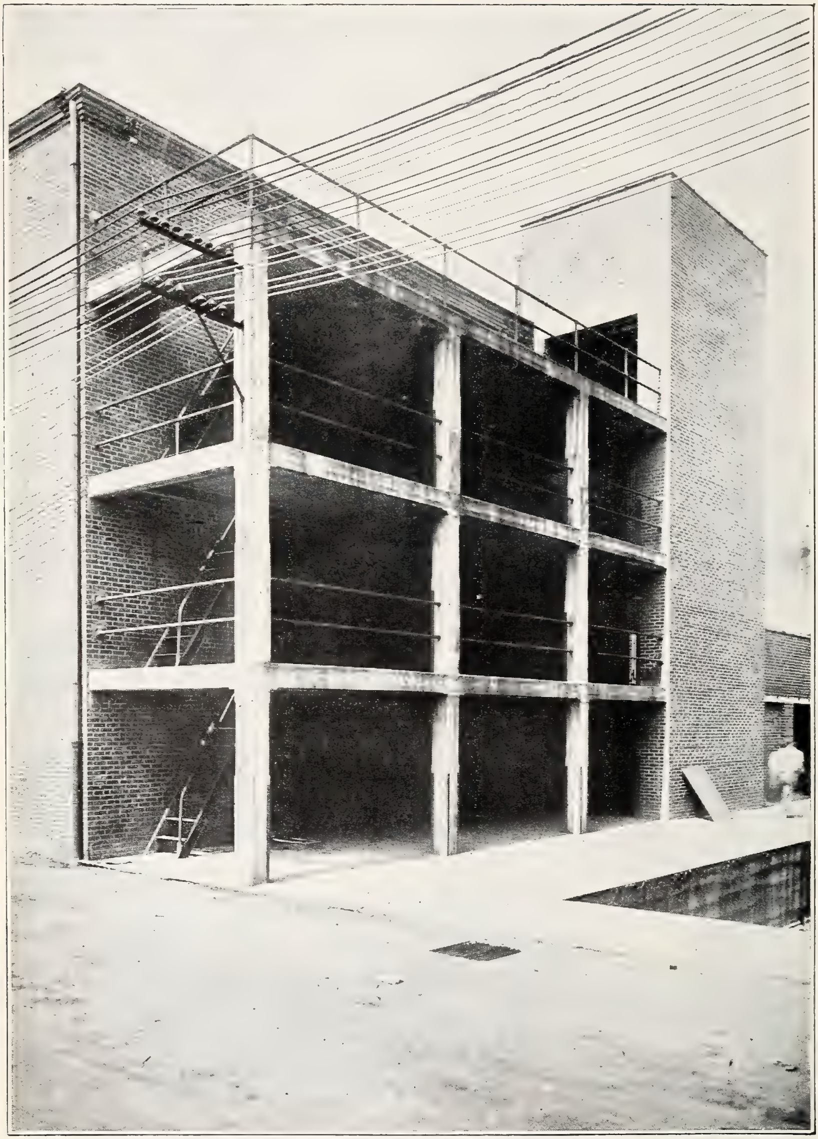
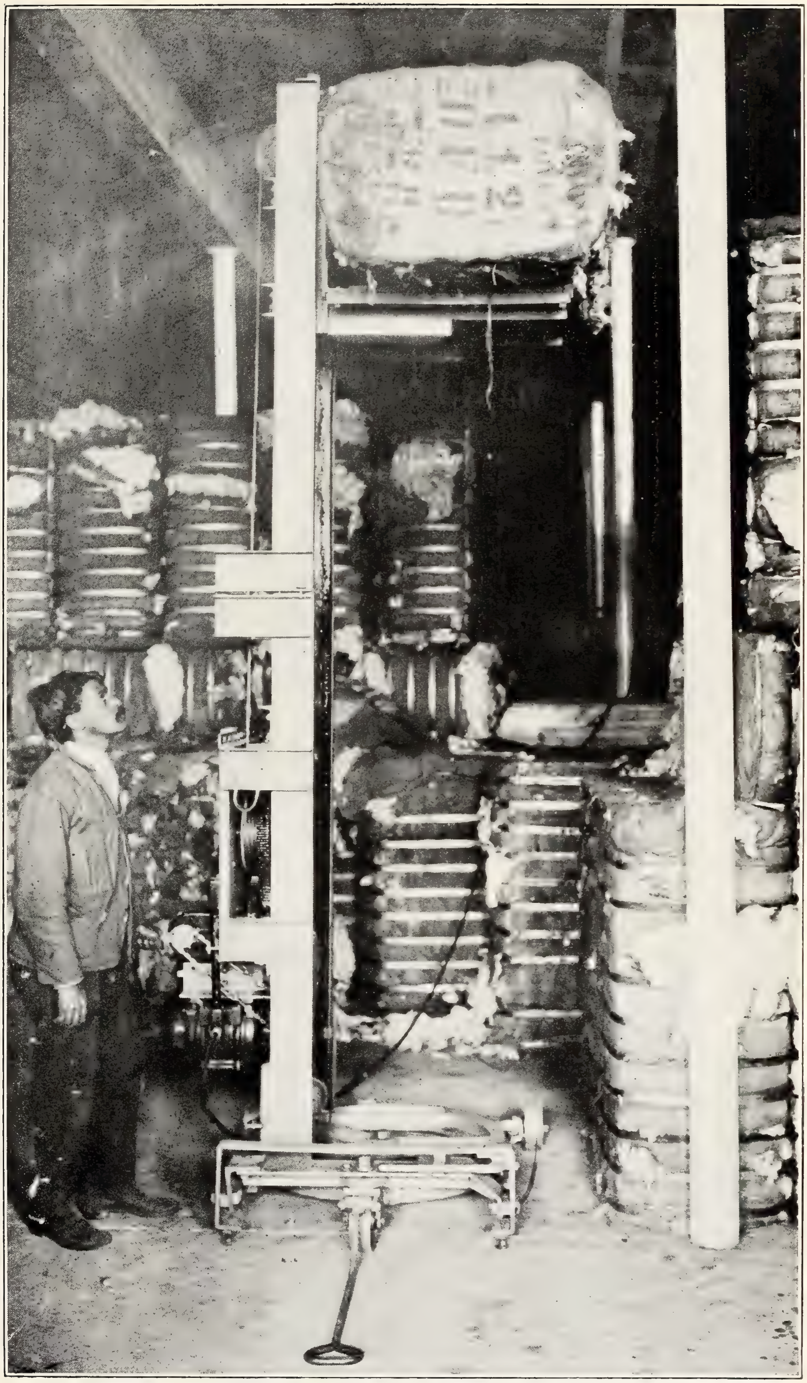


FIG. 2.—THE SPIRAL CHUTE DELIVERS THE BALES AT THE FIRST FLOOR EITHER "HEADED UP" OR IN THE POSITION SHOWN WHICH MAKES LOADING EASY FOR THE TRUCKMAN.



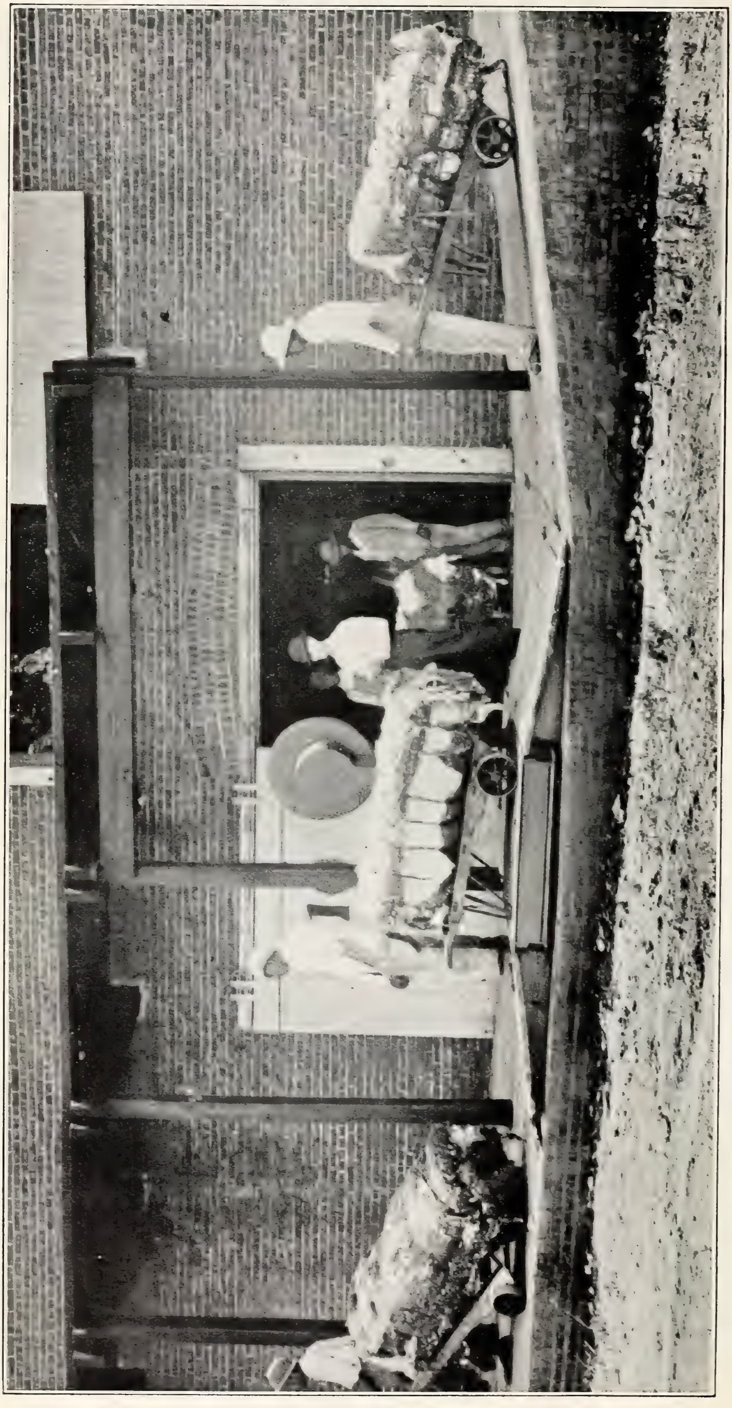
AN EXCELLENT ARRANGEMENT OF ELEVATOR TOWER ON THE EXTERIOR OF THE WAREHOUSE.

Note the neat iron stairs connecting platforms.



THE PORTABLE ELEVATOR, OR PILING MACHINE, MAY BE OPERATED BY HAND OR BY ELECTRICITY.

It is very useful in warehouses where cotton is piled.



A SATISFACTORY ARRANGEMENT FOR USE OF THE PLATFORM DIAL SCALE FOR WEIGHING COTTON.

surance standard of volume having a preferred limitation of 72,000 cubic feet, with progressive penalties in rates of insurance when this volume is exceeded. The limitation of volume is probably the fairest method of limiting capacity in bales.[1]

The area and proportions of the compartment should depend upon still other factors, such as economy of cotton handling, cost of construction, adaptation to withstand fire and to permit effective use of water from sprinklers, hose streams and hand appliances, and adequate daylight diffusion.

The most economical method of handling cotton is that of storing the bales one high on end, but for a plant having a large bulk of its business concentrated in a few months of the year this system requires an investment in buildings and site disproportionate to the capacity. It is economical to provide a story height that will permit of tiering the bales of cotton two high on end, or the equivalent, during the rush season, although the deposits remaining for a large part of the year would probably not require the practice of tiering. This latter system is especially suitable for warehouses used as depositories for producers, or for those whose business necessitates a severe peak load of storage. However, the practice of storing single bales on end in a low-story height compartment is very desirable in such plants as maintain storage fairly distributed over the year, or where there are frequent "turnover," or changes, in the bales stored. This arrangement is adapted particularly to the warehouse of several stories in height.

The influence of cost of construction of the compartment is readily appreciated when it is recalled that the floor and roof of the single story compartment usually cost the same regardless of the exact height of the story. Furthermore, the cost of the walls is but slightly more for a story height of 13 feet (which permits tiering two bales high on end or the equivalent) than for a story height of 8½ feet, as a large proportion of the wall cost is in the part of the wall below the floor and above the roof, the cost of these parts being the same in either case. Moreover, where the sprinkler system is used, the cost per bale capacity is practically cut in half where the story height permits two tiers of bales on end, or the equivalent

---

[1] In computing the volume of a compartment the floor area should be considered as extending to the outer side of exterior walls and between centers of division fire walls, while the height should be taken as the average distance from the first floor to under side of the roof plank or slab measured midway between the high and low parts of the compartment, but not including such additional volume as may be inclosed by skylights. In the case of a fire-resistive floor serving as a fire-break between compartments, the vertical dimension should be the distance from the first floor to such fire-resistive floor, or the distance between successive fire-resistive floors.

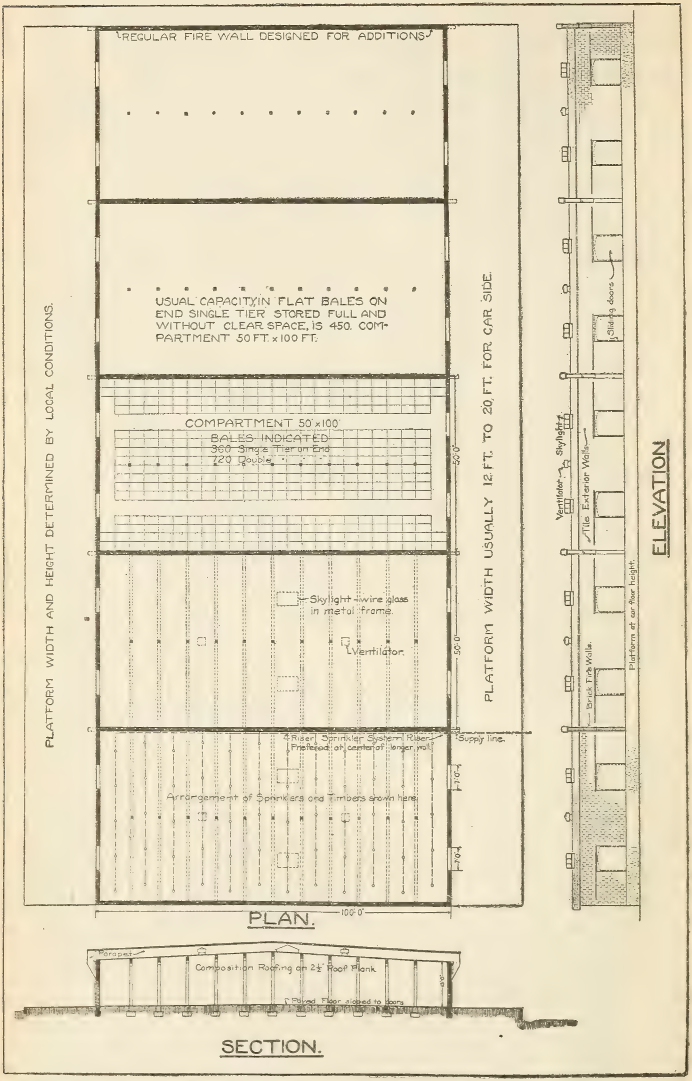

REGULAR FIRE WALL DESIGNED FOR ADDITIONS
USUAL CAPACITY IN FLAT BALES ON END SINGLE TIER STORED FULL AND WITHOUT CLEAR SPACE, IS 450. COMPARTMENT 50 FT. x 100 FT.
COMPARTMENT 50'x100'
BALES INDICATED
360 Single Tier on End
720 Double
Skylight - wire glass in metal frame.
Ventilator.
4 Riser Sprinkler System Riser Prefered at center of longer wall
Supply line.
Arrangement of Sprinklers and Timbers shown here.
50'0"
50'0"
7'0"
7'0"
100'0"
PLAN.
PLATFORM WIDTH AND HEIGHT DETERMINED BY LOCAL CONDITIONS.
PLATFORM WIDTH USUALLY 12 FT. TO 20 FT. FOR CAR SIDE.
Parapet
Composition Roofing on 2½" Roof Plank
Paved Floor sloped to doors
SECTION.
Sliding doors
Skylight
Ventilator
Tile Exterior Walls
Brick Fire Walls.
Platform at car floor height.
ELEVATION

FIG. 1.—A good design for a warehouse of slow-burning or fire-resistive construction. The size of compartments shown is desirable for nearly all conditions.

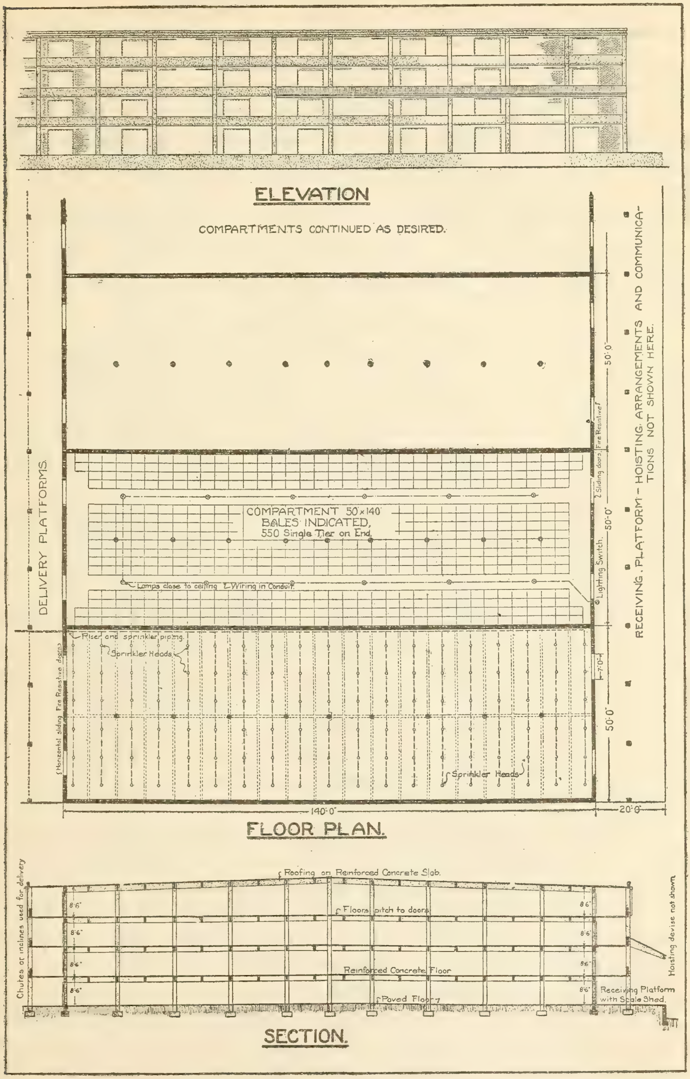

ELEVATION
COMPARTMENTS CONTINUED AS DESIRED.
DELIVERY PLATFORMS.
RECEIVING PLATFORM – HOISTING ARRANGEMENTS AND COMMUNICATIONS NOT SHOWN HERE.
50'0"
50'0"
50'0"
7'0"
Sliding doors, Fire Resistive
Lighting Switch.
COMPARTMENT 50'x140'
BALES INDICATED,
550 Single Tier on End.
Lamps close to ceiling
Wiring in Conduit.
Riser and sprinkler piping.
Sprinkler Heads.
Horizontal sliding Fire Resistive doors
Sprinkler Heads
140'0"
20'0"
FLOOR PLAN.
Roofing on Reinforced Concrete Slab.
Floors pitch to doors
8'6"
Reinforced Concrete Floor
Paved Floor
Chutes or inclines used for delivery
Hoisting devise not shown
Receiving Platform with Scale Shed.
SECTION.

FIG. 2.—A warehouse design suitable for construction of reinforced concrete, or which may be used with timber floors if equipped with automatic sprinklers.

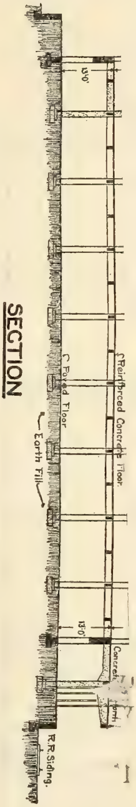
of this with other methods of storage. Again there must be considered the cost of platform, shed, and yard hydrant piping, as well as the land area, all of which unduly increase the cost per bale capacity where the plant is too much expanded or scattered.

Generally speaking, 100 feet may be considered the best length (between exterior walls) for the warehouse compartment. The height of the compartment, while limited by the floor area as regards allowable volume, should be such as to give a minimum of 18 inches between the surface of the cotton and the under side of overhead beams. Where the sprinkler system is installed, the story height should permit the placing of the spray head at least 18 and preferably 36 inches above the cotton as well as a suitable distance (as later specified) from the ceiling.

It is desirable that the compartment be sufficiently light to allow for reading the tag numbers on the bales of cotton. This is one strong influence in favor of the single story compartment, as skylights can be used to good advantage. Where there are a number of stories, compartments not lighted from above should not exceed 100 feet in length unless lighted by electricity.

The above principles are applied in the accompanying plans. Figure 1 shows single story compartments 50 feet by 100 feet in size having a story height of 13 feet, this being a proportion well suited to any type of construction. Compartments suitable for fire-resistive construction are shown in figures 2 and 3 having story heights of 8½ feet and 13 feet respectively. A rather unusual proportion for the compartment, and one which may be justified only by extraordinary limitations of the site, is shown in figure 4. It is worthy of note that this building may be constructed free of columns, with compartments 30 feet wide by 170 feet long. In the case of two-story compartments, which may be applied advantageously to slow-burning construction, the entire volume between fire walls should be considered as a single compartment from the standpoint of fire hazard. The total volume for two stories is slightly in excess of the preferred standards where floors are 50 feet by 100 feet with a story height of 8½ feet, though this particular arrangement involves but a slight penalty from insurance rates, and, where sprinklered, there is less hazard than in a single story compartment where the bales are tiered.

Where funds for the investment are limited, it often may be desirable to build compartments of such area as will give a volume two, three, or even four times the preferred limit of 72,000 cubic feet. In such case it may be well to construct the compartment with a dimension of 100 feet between exterior walls and space division fire walls at such distances that additional walls can be built in later at


SECTION
13'0"
Reinforced Concrete Floor.
Forced Floor
Earth Fill
13'0"
Concrete
R.R. Siding.

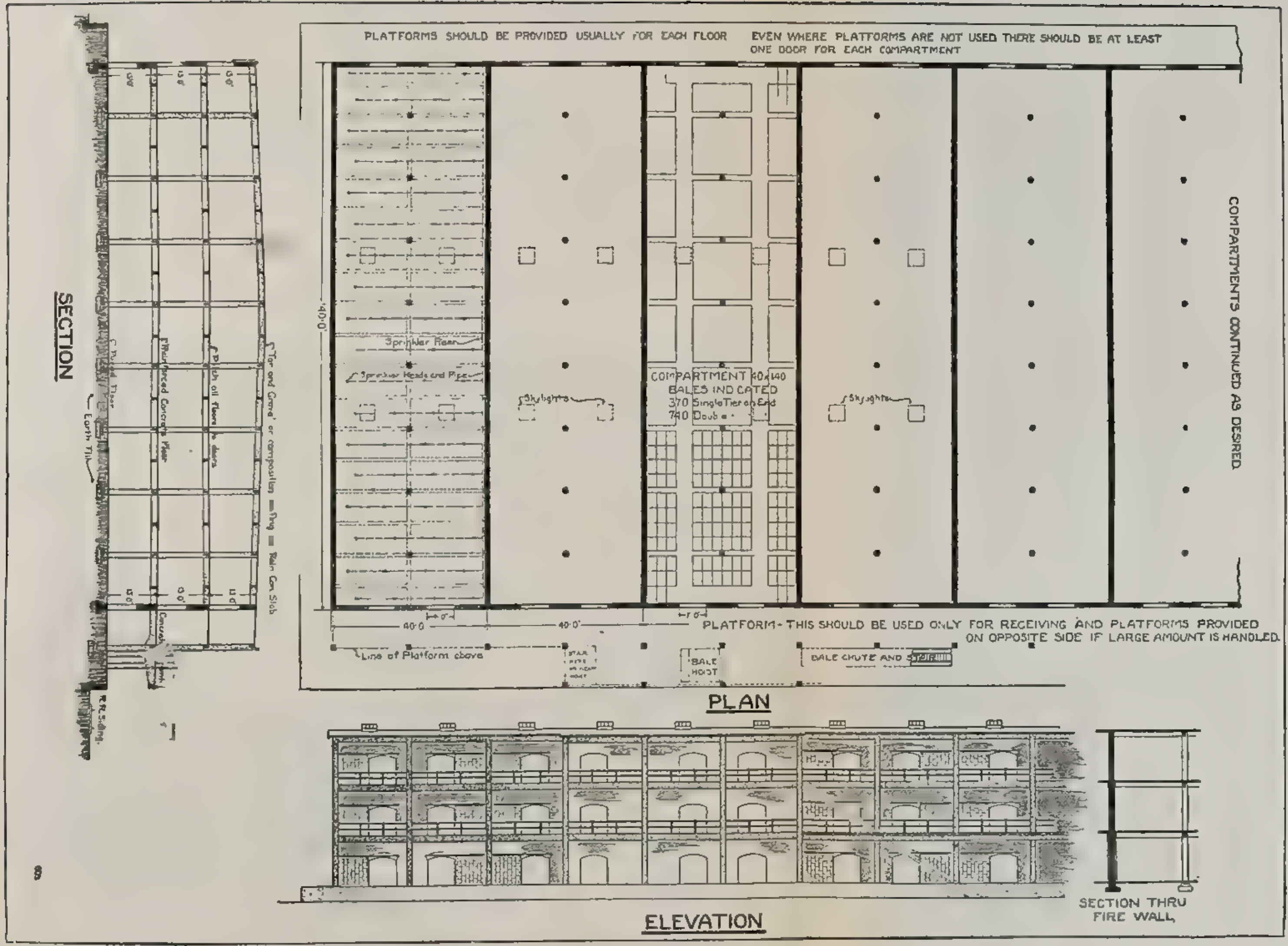

PLATFORMS SHOULD BE PROVIDED USUALLY FOR EACH FLOOR
EVEN WHERE PLATFORMS ARE NOT USED THERE SHOULD BE AT LEAST ONE DOOR FOR EACH COMPARTMENT
COMPARTMENTS CONTINUED AS DESIRED
Sprinkler Riser
Sprinkler Heads and Pipe
Skylights
COMPARTMENT 40×140
BALES INDICATED
370 Single Tier on End
740 Double
40'0"
PLATFORM - THIS SHOULD BE USED ONLY FOR RECEIVING AND PLATFORMS PROVIDED ON OPPOSITE SIDE IF LARGE AMOUNT IS HANDLED.
Line of Platform above
BALE HOIST
BALE CHUTE AND STAIR
PLAN
ELEVATION
SECTION THRU FIRE WALL
SECTION
Tar and Gravel or composition Roofing on Rein. Con. Slab
Pitch all floors to doors
Reinforced Concrete Floor
Earth Fill
R.R. Siding

FIG. 3.—A warehouse design suitable for construction of reinforced concrete.

128983—19. (To face page 12.)

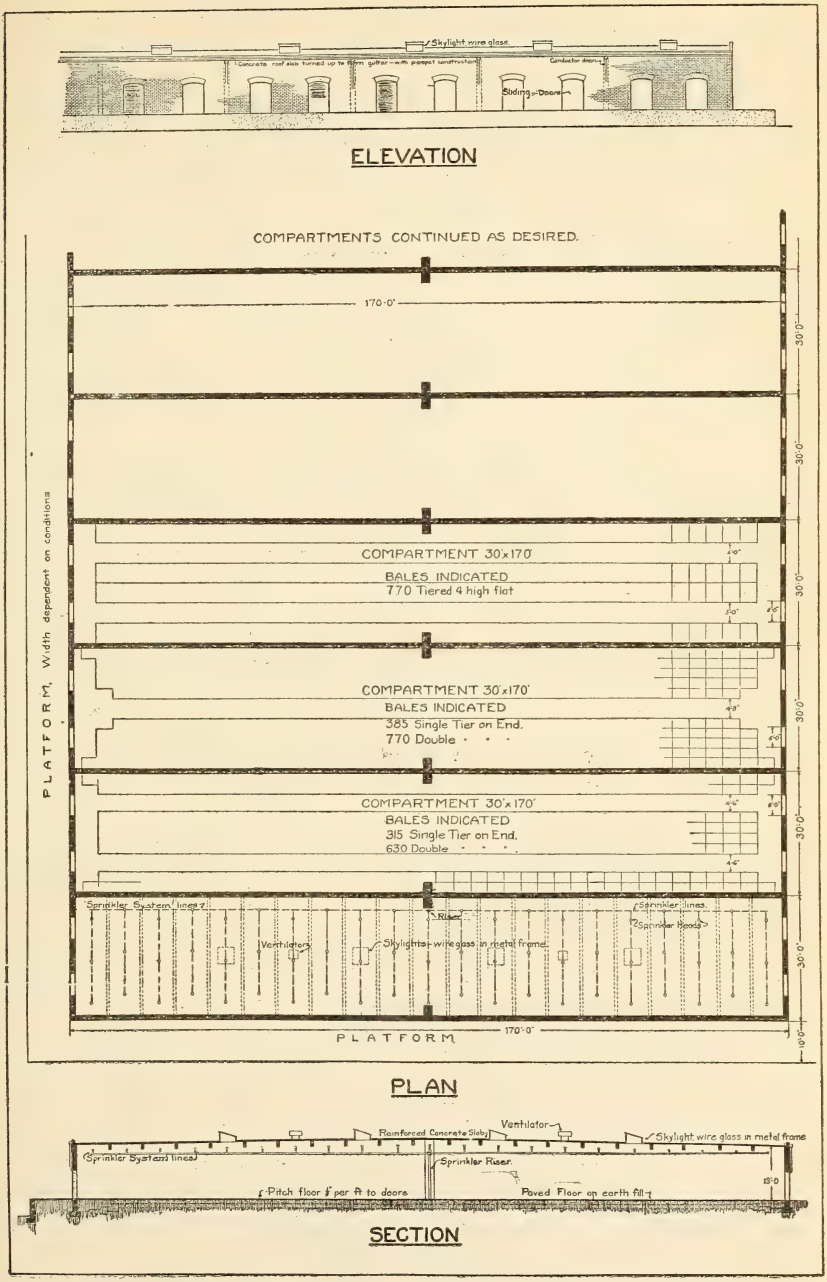


FIG. 4.—A warehouse design having long compartments free of columns.

intervals of 50 feet forming compartments 100 feet by 50 feet in size. When the building is first planned the story height should be so fixed that compartments thus formed will have a volume not exceeding the preferred limit of 72,000 cubic feet. Thus a building may be constructed which has a low first cost but which may be improved very economically later with an effective saving of fire hazard and insurance charges. Another desirable method of reducing first cost and yet providing for future improvements is to use a story height of 17 feet (at the eaves) and provide corbels or pockets in the walls to support a second floor to be built in later. In this way automatic sprinkler protection can be given to a large capacity and later the added floor and discontinuance of tiering will secure convenience and economy in handling and advantageous protection for the cotton. The sprinkler system would have to be extended so as to cover the lower floor. This should be anticipated in the beginning and supply pipes made large enough to care for the additional heads.

The compress compartment demands, for practical use, a greater area than is recommended for the storage compartment. Here tiering of cotton is not to be countenanced from the standpoint either of practical cotton handling or fire hazard. However, requirements for good light and ventilation, as well as the convenient operation of some types of weighing apparatus in use, make a story height of approximately 15 feet desirable. For these reasons the capacity permissible is better expressed in terms of square feet of floor area. This area usually should not exceed 22,500 square feet, this being equivalent to a floor 150 feet square. Where this space is not sufficient, a similar compartment may be provided adjacent to the compress compartment and communicating with it through well protected fire doors in the dividing fire wall.

Arrangements for the compress compartments are shown in figures 5 and 6. Figure 5 shows how the compress may be divided into six compartments, all communicating directly with the compress compartment, without openings in the fire walls except for those doors leading directly to the press room. These arrangements provide for a detached boiler room which is always to be desired, though a corner of the press room may be cut off by fire walls for this use. The second plan (fig. 6) provides compartments on each side of the press compartment. Both of these plans may be adapted readily to either fire-resistive or slow-burning construction. If slow-burning construction is used, roof openings such as skylights should be of metal, and wooden monitors should be placed at least 50 feet from fire walls.

The types of construction which are desirable for the warehouse building are fire-resistive, slow-burning, and a modification of this

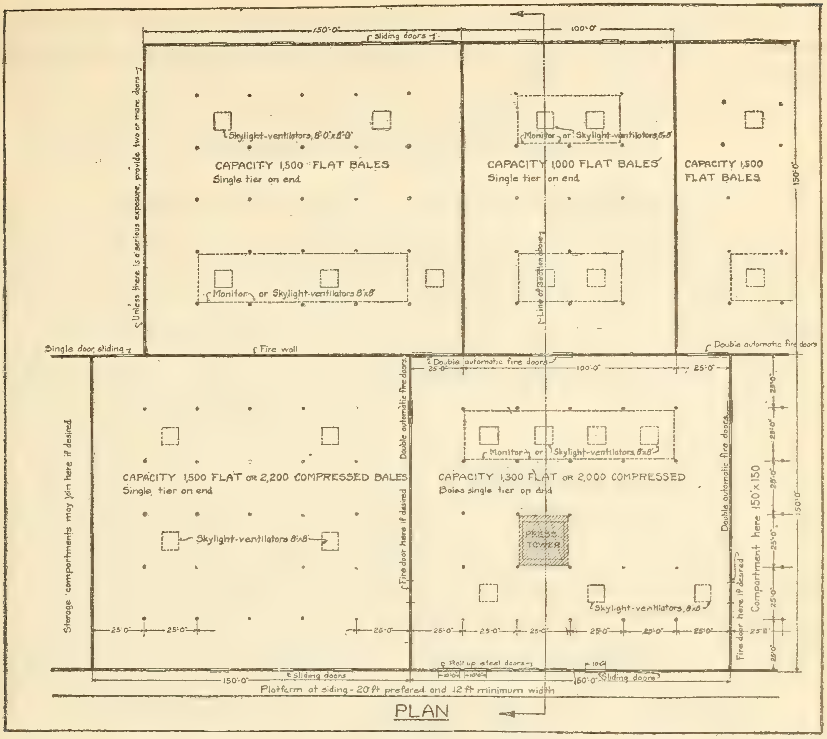

150'-0"
Sliding doors
100'-0"
150'-0"
Unless there is a serious exposure, provide two or more doors
Skylight-ventilators, 8'-0"x8'-0"
CAPACITY 1,500 FLAT BALES
Single tier on end
Monitor or Skylight-ventilators 8'x8'
Monitor or Skylight-ventilators, 8'x8'
CAPACITY 1,000 FLAT BALES
Single tier on end
CAPACITY 1,500
FLAT BALES
Line of section above
Single door, sliding
Fire wall
Double automatic fire doors
Double automatic fire doors
25'-0"
100'-0"
25'-0"
Storage compartments may join here if desired
Double automatic fire doors
CAPACITY 1,500 FLAT OR 2,200 COMPRESSED BALES
Single tier on end
Skylight-ventilators 8'x8'
Fire door here if desired
Monitor or Skylight-ventilators 8'x8'
CAPACITY 1,300 FLAT OR 2,000 COMPRESSED
Bales single tier on end
PRESS TOWER
Skylight-ventilators, 8'x8'
Double automatic fire doors
Fire door here if desired
Compartment here 150'x150
25'-0"
150'-0"
Roll up steel doors
10'-0"
Sliding doors
150'-0"
50'-0"
Sliding doors
Platform at siding - 20 ft prefered and 12 ft minimum width
PLAN

FIG. 5.—A compress arrangement which permits of access to five compartments without their connecting with each other.

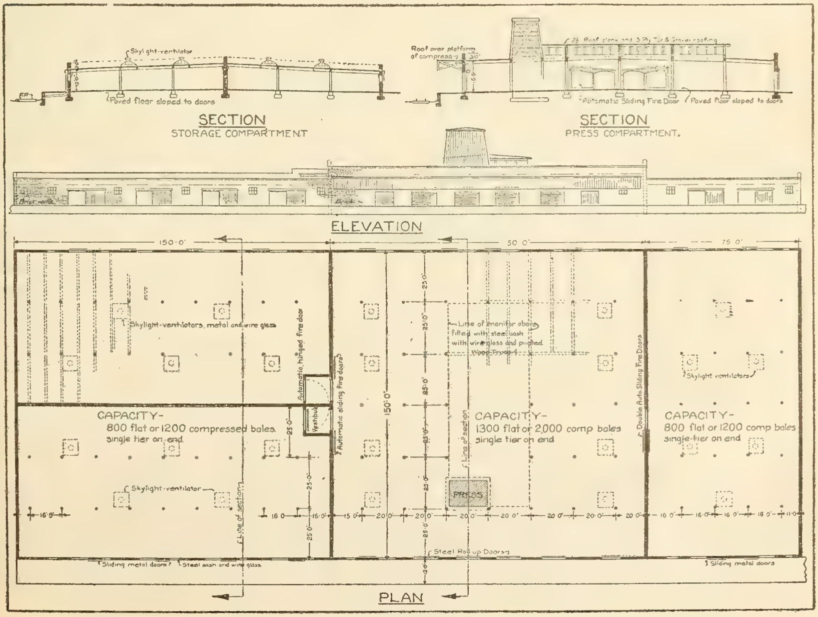

Skylight-ventilator
Paved floor sloped to doors
SECTION
STORAGE COMPARTMENT
Roof over platform of compress
2½ Roof plank and 5 Ply Tar & Gravel roofing
Automatic Sliding Fire Door
Paved floor sloped to doors
SECTION
PRESS COMPARTMENT.
Brick walls
Brick
ELEVATION
150'-0'
50'-0'
75'-0'
Skylight-ventilators, metal and wire glass
Automatic hinged fire door
Automatic sliding fire doors
Vestibule
Line of monitor above fitted with steel sash with wire glass and pivoted Wood Truss
150'-0"
Double Auto Sliding Fire Doors
Skylight ventilators
CAPACITY-
800 flat or 1200 compressed bales
single tier on end
CAPACITY-
1300 flat or 2,000 comp bales
single tier on end
CAPACITY-
800 flat or 1200 comp bales
single-tier on end
Skylight-ventilator
Line of section
PRESS
Steel Roll up Doors
Sliding metal doors
Steel sash and wire glass
Sliding metal doors
PLAN

FIG. 6.—A good arrangement for compress and adjacent storage compartments. Additional compartments may be continued at either end of the building.

type which may be called semi-slow-burning (or "wood-end") construction. In addition to these, there is the less desirable frame and "iron clad" construction.[1]

FIRE-RESISTIVE CONSTRUCTION.

Fire-resistive—sometimes called "fireproof"—construction for the warehouse ranks first both in protection against fire and in low cost of maintenance and depreciation charges. However, the first cost is more than that for the other types of construction. For this reason it is not to be preferred usually to the best design of slow-burning construction, for single story warehouses. On the other hand, fire-resistive construction should be used for warehouses several stories high whenever possible, and for the single story plant which is badly congested or severely exposed. Discussion of fire-resistive construction is taken up first so as to treat fully such subjects as masonry and other details common to the several types of construction.

---

[1] The adaptation of the compartment to withstand fire and admit of effective use of fire protective equipment is of great importance. The features of construction will be discussed under that heading, but it may be stated here that effective use of hose streams demands that the length of the compartment, or the distance between exterior walls, usually should not exceed 100 feet. Exceptions to this rule are the cases of fire-resistive construction where there is but one story with large skylights through which streams of water may be thrown to the center of the building, and where the construction is fire-resistive, of several stories and fully protected by sprinkler equipment. In the latter case the increased length of the compartment would be desirable in order to reduce the cost of the platforms. In this case the compartment length (between exterior walls) should not exceed 150 feet.

Compartments may be combined horizontally in considerable numbers, the only limitation being that single combinations constituting one building should not be so long that in case of fire it would require an unreasonably long time for a fireman or other person to pass around the building from one side to the other. Usually the building should not exceed 700 feet in length, and there should be an open space between the ends of these buildings of at least 50 feet, unless the exterior walls are of substantial masonry, in which case a 25-foot space is sufficient.

The whole consideration of size of compartments is, of course, an effort to restrict fire damage. Any definite limit is necessarily arbitrary. The limit of 13 feet in story height is well adapted to the storage of flat cotton two bales high on end or one tier on end and two tiers flat, and is a suitable proportion where bales are stored entirely on the side as is frequently the case for compressed cotton, bales in this position are piled five high. In this latter case additional story height results in less effective use of automatic sprinkler (see section on fire protection), and other fire-extinguishing equipment to such an extent that the maximum should not exceed 18 feet. There should also be taken into account the fact that usually with the increased height, additional cotton is subjected to fire. As previously stated, the best distance between exterior walls is 100 feet and this should not be exceeded except under conditions similar to those explained, and in no usual case should the distance exceed 200 feet. The remaining dimension for the compartment—the distance between division walls—may be adjusted entirely in reference to the value of cotton thus subjected to a single possible fire. Preferably this dimension should be such as to limit the volume of the compartment to 72,000 cubic feet.

DISTINCTIVE ADVANTAGES AND FEATURES.

Essential features of fire-resistive construction are the superior fire-resistive nature of material used in construction of all walls, floors, roof, structural members and details, together with such arrangement and assembly of this material as will protect the contents of the building against fires of external origin and the spread of fires originating inside, and will result in minimum damage to the building itself. It should be noted that any type of building in which combustible material is stored may be subjected to the most severe test from internal fires. Therefore the construction of the building should be such as to withstand an intense and sustained fire and, at the same time, afford the best opportunity for use of fire-protective equipment. The important features of this construction may be considered as the division fire walls, exterior walls, roof, floors, and openings.

TYPES OF WALLS.

Until comparatively recent years all walls supported their own weight and usually a part of the load imposed by roof and floors. This type of wall is known as a "bearing wall." It is the type generally used for the cotton warehouse, both as the division fire wall between compartments and as the exterior wall where this is of masonry. With the introduction of the steel and reinforced concrete buildings there came into use two other types of wall—the "curtain wall" and the "panel wall." The curtain wall, which merely carries its own weight, is often used in commercial buildings, though it is seldom used in the cotton warehouse; when it is so used, the same limitations fixed for the bearing wall will be found applicable. The panel wall is especially well suited for reinforced concrete construction and so presents advantages for some warehouse designs. In the usual construction, the wall is built in panels formed by the structural frame, the portion inclosing any story being supported independently. Division fire walls and exterior walls, for fire-resistive construction, present somewhat different requirements and therefore are discussed separately. In both instances, thickness and other provisions stated are based on brickwork and refer to the usual bearing wall, while modifications of these requirements are stated in connection with other materials and the different designs of walls.

DIVISION FIRE WALLS.

Division fire walls should extend from a firm foundation of concrete or other masonry to the underside of the roof, but need not extend through the roof. The end of the division fire wall may be built into the exterior wall where this exterior wall is of material equal to that used in the division fire wall; but if the exterior wall is of even slightly inferior material, the division fire wall should extend through to the outside of the exterior wall. Otherwise, division fire walls for fire-resistive construction are not essentially different from division walls for other types of construction. The division fire wall for a building of several stories may be constructed solidly with floors resting on offsets (or corbels), or reinforced concrete floors may extend through the wall.[1]

The proportions and design of the division wall should be adapted to the general design of the buildings and the material available for the wall. In no case should the division wall be less than 16 inches in thickness except for reinforced concrete panel walls referred to later. With this as a minimum, walls of concrete properly reinforced with steel may be 4 inches less in thickness than is required for brick, while walls of plain concrete should be 4 inches thicker than the nominal thickness required for brick because of the fact that severe or concentrated heat will produce such unequal expansion in a thin wall as would be likely to cause dangerous cracks or crumbling.[2]

---

[1] The requisites for material for the construction of a division fire wall are, first, that it will not transmit heat rapidly; second, that it will not deteriorate under the test either of quick and severe or of sustained fires; third, that it will absorb heat with sufficient uniformity to obviate dangerous difference in resulting expansion between the protected side of the wall and the side exposed to fire. Even with the best materials it is essential that the proportions and design of the wall be such as to resist the stresses resulting from the fire and give sufficient stability to the wall.

Material best suited for division walls are hard brick (of clay or clay and shale) laid in cement mortar, reinforced concrete, or plain concrete. All of these materials offer a strong resistance to the transmission of heat and are not deteriorated by it to a dangerous degree. Furthermore, they absorb heat with sufficient uniformity to prevent variation in expansion which results in spalling, or the flaking off of large pieces. These are qualities lacking in many stones, especially limestones and granites; limestone will crumble when subjected to heat and granite will break up badly. It is for this reason, chiefly, that division walls should not be constructed of stone. Mortar composed largely of lime deteriorates from heat, and, therefore, brickwork should be done with cement or cement-lime mortar.

It is the requisite that a material absorb heat and expand uniformly that is the chief objection to the use of hollow clay tile in division fire walls. The feature of insulation formed by the air pockets or cells—which makes this material so desirable for certain uses—totally unfits it for use in a division wall. During a fire, the exposed shell of the tile expands very rapidly and the air cell prevents sufficient absorption of heat by the protected portion of the tile, with the result that the thin shell cracks or the wall buckles because of the excessive expansion of one side.

The proper increase in thickness for a division fire wall beyond that set as a minimum depends largely on the height and number of stories and the length (unbraced) of the wall. Discussion of the thickness has reference to brick bearing walls, while the provisions for other material and designs explain the modification such change would involve. The number of stories and their height should be the first consideration in determining the thickness, and should be based on a wall not exceeding 100 feet in length. For a single story building having a story height not exceeding 18 feet at the lowest or 20 feet at the highest part of the roof adjacent to the division wall, such wall should be 16 inches thick, while for every additional 12 feet or fraction thereof in height this thickness should be increased 4 inches. If the wall is several stories in height, the minimum wall thickness for the two top stories should be 16 inches, while for each two successive stories below (each not over 15 feet

---

Where tile is used as panel walls in a frame of reinforced concrete or between piers of concrete or heavy masonry, this danger is intensified because the tile is securely restrained by the piers or concrete frame which expands much more slowly with the result that the tile is subjected to an expansive stress which is likely to destroy it. The idea that the tile is destroyed by the formation of steam at such pressure as to cause an explosion is not tenable for the reason that sufficient moisture is not always present and, where it is, the mortar joints are rarely sufficiently tight to prevent the escape of steam as it forms. The cracking of tile when water is applied is due to uneven contraction from sudden cooling. These statements appear in conflict to the use of tile for insulation of steel frame buildings. This, however, is a use where the arrangement of the tile permits more expansion as it is less restrained, and usually the fire is less severe. However, experience has shown that even here clay tile affords much less protection than brick or concrete, which now is being used for protecting important columns.

[2] This action in a concrete wall adequately reinforced with steel would not occur to a serious extent, while in a brick wall the bonding or tying together of the face or outside brick would result in a decided tendency to limit the penetration of the damage to the outer 4 inches of the thickness of the wall. Furthermore, the wall of unreinforced concrete affords a chance for concealment of dangerously poor workmanship which the introduction of steel reinforcement would tend to overcome. The thickness of 12 inches, or even 10 inches for reinforced concrete panels, is entirely satisfactory in retarding the passage of heat, though it must be increased when required by certain conditions.

in height, from floor surface to floor surface) or each increment of 30 feet, the wall should be increased in thickness 4 inches.[1]

The foregoing thicknesses apply to a wall not more than 100 feet long. If this length is exceeded the thickness of the wall should be increased 4 inches throughout for each additional 100 feet or part thereof, except that for reinforced concrete the increased thickness may be one-half that stated above.[2]

While it is not intended to discuss here the matters pertaining to all details of a building code, it may be well to point out some dangers of poor construction in the division fire wall. Openings in division fire wall should be avoided as far as possible. It seldom is necessary to provide any openings in such a wall of a warehouse storage compartment, though openings frequently are necessary in compress compartments to connect them, or to connect the compress with the adjacent storage compartment. In any case the opening should be as small as is practicable and should conform to the limitations stated later in the discussion of the doors themselves. Construction and design of fire doors is discussed in detail later.[1]

---

[1] For the final 4 inches of thickness in excess of 16 inches pilasters may be substituted provided such pilasters are built with the wall, are opposite each other on both sides of the wall, and are located and proportioned suitably. Such pilasters should have a projection from the wall of 4 inches on each side, and the face (or dimension parallel to the wall) should be a minimum of 16 inches and not less than one-eighth of the spacing of the pilasters measured between centers. The spacing of pilasters should not exceed 25 feet. The location should be such that no part of the wall will be loaded beyond the allowable unit working stress of the material used.

[2] While stated thicknesses for walls seem arbitrary, the explanations made show that a division wall is subjected to more severe tests during a fire as the height or length of the wall increases. Difference in thickness of brickwork necessarily must be made in units of 4 inches, and so heights and lengths of walls stated are adjusted to this variation. Good practice has shown that the above thicknesses are very satisfactory for a wall serving as a barrier against fairly intense and continued heat. A wall of less thickness may afford good protection, but it should be borne in mind that a division fire wall should represent "the last line of defense" in a fire; and if the values behind the wall justify the expense of a wall, then one which will afford dependable protection is the best investment.

An exception to some of the foregoing requirements for a division fire wall is found in panel-wall construction especially adapted to reinforced concrete roof and floors. The panels may be built of brick between supporting columns and floor and roof slabs or beams, after these have been constructed, or the panels may be of reinforced concrete cast with the floors. In such a case the stability of the wall and its action in resisting expansion is cared for by the concrete framework, and each panel of brickwork may be treated as a separate and independent division wall in applying the preceding requirements. These requirements for thickness, however, may be modified to the extent of permitting a brick panel wall to be only 12 inches in thickness, or a reinforced concrete panel 10 inches in thickness, for a height of 20 feet for panels not exceeding 30 feet in length. The mortar used for laying brick walls of this character should be the cement-lime mortar described, as it is more compressive, and so in this confined position may withstand the severe compression from expansion. This form of construction usually will not be economical as compared with the regular division wall carrying the floors and roof, except in case the building is more than four stories high or the wall is excessively long or there are such special conditions as are discussed under the heading of roof and floor construction.

---

[1] If brick is used they should be well burned and at least two-thirds of them hard (or fully burned), the "run-of-kiln guaranteed two-thirds hard" being satisfactory. Care should be taken to see that extremely soft brick from the outside of the kiln are thrown out. The harder brick of the lot should be used for the exposed surfaces of the wall, and the softer brick used for filling in between.

The brick should be laid fairly close together with joints well filled with mortar. Ample "bond" or "header" courses should be used to tie the parts of the wall firmly together, this tie being used for every sixth course. The work should not be carried on in freezing weather, while if the weather is warm and dry the brick should be wet before they are laid, as this prevents too rapid drying of the mortar. The mortar used for the fire wall preferably should contain a mixture of one part Portland cement, one-seventh part lime (either putty or hydrated), and sand not exceeding three parts, and should be mixed only as required for use. A fairly satisfactory mortar for use above the ground, however, may contain one part Portland cement, one part lime (either putty or hydrated) and six parts sand. Cement should not be added more than one-half hour in advance of use of the mortar.

When concrete is used, it should be prepared under competent supervision, while the actual work can be done largely by unskilled labor. Mixing and casting should not be done in freezing weather. Concrete not reinforced with steel should contain one part of Portland cement, two and a half or 3 parts sand, and five parts of suitable gravel or crushed stone. The chief dangers to be guarded against are leakage of the form in which casting is done, insufficient mixing, and careless packing or tamping. Concrete reinforced with steel, as used for walls, should conform to the requirements later stated in reference to "Reinforced concrete." The top of the opening should be formed by a substantial brick arch or a concrete lintel. Steel or iron lintels may be used provided they are protected by either 4 inches of brickwork or a complete overlapping of the door. The threshold should be of iron or steel, securely anchored, or the sill (including the part against which the door closes) may be of concrete 6 inches or 9 inches thick and fully supported by the wall. An example of 4 by 4 inch steel angles used with concrete is shown by Plate XIV, figure 5. A solid cast-iron threshold with the surface roughened is to be preferred. The threshold should be raised 1½ inches or 2 inches, with the floor sloped up to this level, so that water used to extinguish fire in one compartment will not flow into the one adjoining.

Vestibule doorways afford excellent protection of the opening. An example of such an arrangement is shown by Plate XIV, figure 6, where the low story makes the arrangement shown fairly economical. Where the story is very high the vestibule may be constructed with a low ceiling covering slab. The width of the vestibule corresponds to the width of doors, while for the depth, or distance provided between the doors, 6 feet is sufficient unless it is desired to use one swining door opening into the vestibule, as is shown by the drawing. In such sase the minimum distance of 6 feet would be increased to suit the width of door used.

EXTERIOR WALLS.

The exterior wall of the fire-resistive warehouse should be of noncombustible material. It need not, however, be of such material and design as to offer as long-sustained resistance to fire as the division wall unless that particular exterior wall has a very hazardous exterior exposure, in which case it should conform to requirements for a division fire wall. The material suitable for the usual exterior wall is not as limited as is the case for the division fire wall. Brick, concrete (with or without steel reinforcement), stone, and sand-lime brick are all acceptable, and usually are to be given preference in the order named. Where there is no exposure hazard, hollow cement blocks and hollow clay wall tile may be used for panel walls of two-story buildings, but even in this case the adoption of this material for a fire-resistive warehouse is not desirable.[1]

In discussing exterior walls, brickwork is the basis for stating thickness, just as it is for the division fire wall, but in this case no increased thickness is required when plain concrete is substituted for brickwork. (In this connection it is well to note the requirements for "panel walls" set forth later.)

The exterior wall of the usual bearing type which supports floors and roof may be 4 inches less in thickness than was specified for a division fire wall, provided the minimum thickness be 12 inches for the first story, where the height of the story does not exceed 18 feet, and that where there is more than one story the wall for the top story should not be less than 12 inches thick. In applying the rule for increased thickness for long walls, only that portion of the exterior wall which is between division fire walls need be considered.[1]

---

[1] Brick, cement blocks, and stone may be laid in lime mortar, except that for the portion of the wall below and 2 feet above the ground level, the cement mortar, previously mentioned, should be used. The lime mortar should contain one part lime putty, or hydrated lime, to not more than four parts sand, the exact proportion being adapted to the character of the sand used. (See U. S. Bureau of Standards Circ. 30; Lime: Its Properties and Uses, 1911.) The replacement of one-fourth of the lime with a like amount of Portland cement will give excellent results without a great increase in cost. In this case the mortar may be mixed in advance and the cement added as the mortar is used. These mortars are equally suitable for the cement blocks.

Walls of brick—either clay, clay and shale, or sand-lime—and of concrete with and without reinforcement may be used to support the roof and floor, this construction being a "bearing wall." In case of walls of cement blocks or clay tile it is best that the floor and roof slab be supported independently by columns and beams and that the wall be built independently so as to be tied to the floors and columns in such manner that the wall will support only its own weight, thus forming a "curtain wall." In case the building is a number of stories in height and the tile or blocks are used it will be better and more economical to use a "panel wall" built between the columns and beams in such manner that the inclosing wall for any floor is supported by that floor and not by the wall for the story below.

Windows in the exterior wall should consist of steel sash glazed with wire glass and should be stationary unless ventilation is needed. They need not be fitted with fire shutters unless the exposure is severe. The windows should be placed high so as to throw light over the top of the cotton bales. Windows may be omitted and light supplied by skylights in the case of the single-story warehouse. If ventilation is to be supplied by the window the opening should be screened, and the sash hinged at the top and controlled by a fusible link and hook. The window has one advantage other than supplying light in that it affords a ready opening through which a hose stream may be discharged effectively. Usually, however, doors supply this need.[1]

---

[1] Curtain walls may be of the same material as the bearing wall; or clay wall tile or cement blocks may be used, provided the thickness of the wall is made the same as for brick and in addition provides exterior pilasters having a projection of one-third the wall thickness and spaced at intervals not exceeding eight times the width of the pilaster. For example, a single-story building having a story height of say 13 feet, or not exceeding 18 feet, should provide an exterior wall of 12 inches thickness, which could be of brick, concrete, stone, cement blocks, or clay tile, but if the wall is of cement blocks or clay tile, it should be stiffened and braced on the outside by pilasters having a projection from the wall of 4 inches—that is to say, the thickness of the wall measured through the pilaster should be 4 inches greater than that of the space between pilasters. If the pilasters are 2 feet wide, they should be placed 16 feet apart, while if they are only 1 foot wide they should be placed 8 feet apart—measuring from the center of one pilaster to the center of the next. However, the usual concrete wall column, if extending entirely through the thickness of the wall, is a satisfactory substitute for a pilaster of 3 feet width.

Panels for the exterior wall may be of less thickness than was stated for the division fire wall, panels of reinforced concrete may be only 6 inches thick, while panels of brick and plain concrete may be of 8-inch thickness provided the height of the panel does not exceed 12 feet, though for cement block, clay tile and stone masonry panels, the height should be limited to 10 feet for an 8-inch thickness, additional height necessitating the usual progressive increases in thickness as stated for bearing walls.

Clay tile should be laid with cement-lime mortar and joints three-quarters or 1-inch thick as the mortar serves as a cushion and tends to prevent cracking of the tile from heat. Better work usually will be secured by laying the tile on side rather than on end, as the narrow surface of the tile shell affords but little area for mortar, making it difficult to secure the thick joint desirable. Door openings in the walls should be formed of brick as otherwise the corners of the tile are likely to become badly broken from trucking, thus affording an opportunity for entrance of sparks as well as being unsightly. For walls which do not contain windows, tile offers some advantage in that it can be broken through readily to provide an opening for hose streams.

EXTERIOR DOORS.

Doorways in the exterior wall should be provided in such size and location as may be convenient to the warehouse operatives, and at the same time serve the purposes of the fireman. Convenience in trucking is favored by a wide door, most situations being met advantageously by a door opening 7 feet wide and 6½ feet high. The width, however, may range from 6 feet to 8 feet and the height should not exceed 10 feet. The exterior, or end, wall of the storage compartment ordinarily should have doors at intervals not exceeding 40 or 50 feet apart, measuring from centers of the doors, and usually not less than two doors. The threshold of the doorway should be of cement or iron. It should have a slope outward of 1 inch or more to prevent entrance of blowing rain. The top of the opening should be an arch of the wall material or a lintel of reinforced concrete or steel. For the compress compartment doors may be as numerous as desired and of a width up to 12 feet. It is convenient to have practically the whole wall near the press consist of steel doors arranged to roll up. (See Pl. XIII, Fig. 1.) Certainly the compress compartment should have at least as many and as large doors as should the storage compartment.[2]

---

[1] There is another kind of opening that should be provided in the exterior wall. This is known as a "scupper" which consists of an opening in the wall at the floor level for the purpose of discharging water which may accumulate on the floor from any unusual cause, such as the discharge of water from the sprinkler system. Scuppers should be of suitable size and design for the number used to discharge, under 3-inch head of water, 100 gallons per minute for each 500 square feet floor area. Each scupper should have a capacity of not less than 100 gallons per minute under 3-inch head of water, and should meet the other recommendations of the National Fire Protection Association.

[2] An exception to the usual minimum for door openings may be made in case it is not desired to provide doors for ordinary use such as would be true of upper stories not served by platforms on that side. In such instances at least one door should be provided for use of firemen unless the wall is so exposed to other buildings as to make the door a hazard. This type of door should be not less than 4 feet wide, fire-resistive and arranged to swing out. It should be secured by such hardware that it could be locked to the outside but not the inside, the idea being that it should not offer any resistance to firemen shut off on the inside and that firemen seeking to gain access should be able to break the door open without delay. This may be accomplished very simply by a few links of a chain passed through a hole in the door, the inner link being secured by a hook and the outer link by a padlock. Such a door is shown by Plate XVIII, figure 6, and is used for only the upper floors. The landing formed by the projection of the floor slab is very desirable for doors high above the ground.

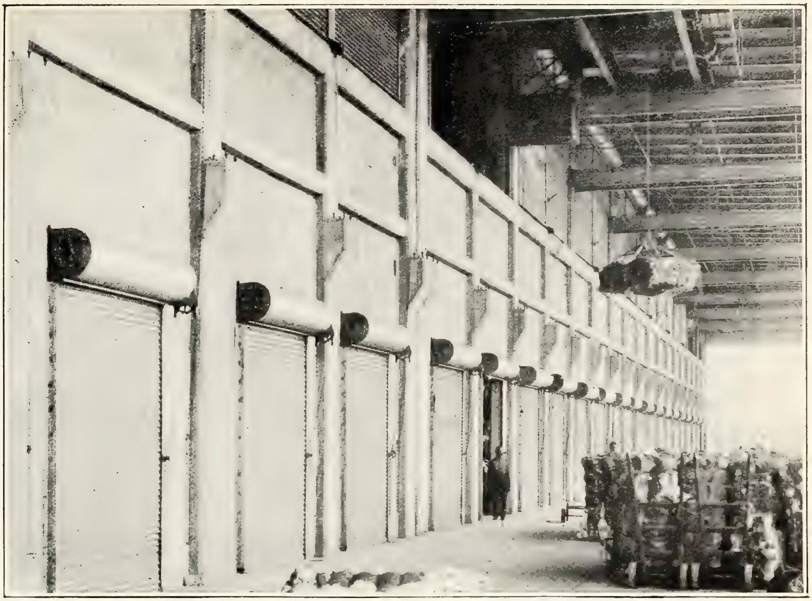


FIG. 1.—ROLL-UP STEEL DOORS ARE EXCELLENT FOR THE COMPRESS COMPARTMENT.

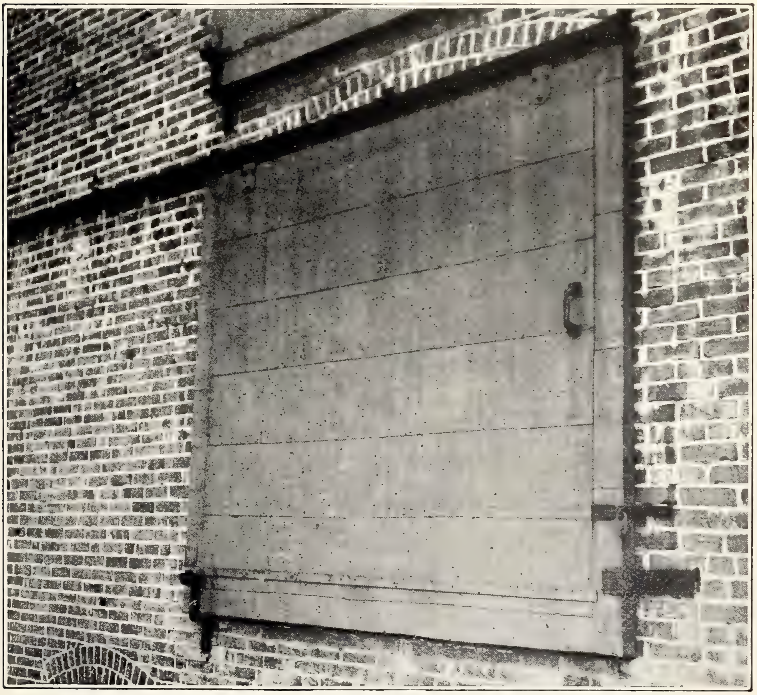


FIG. 2.—A TIN-CLAD DOOR OF A GOOD DESIGN FOR USE IN THE EXTERIOR WALL.

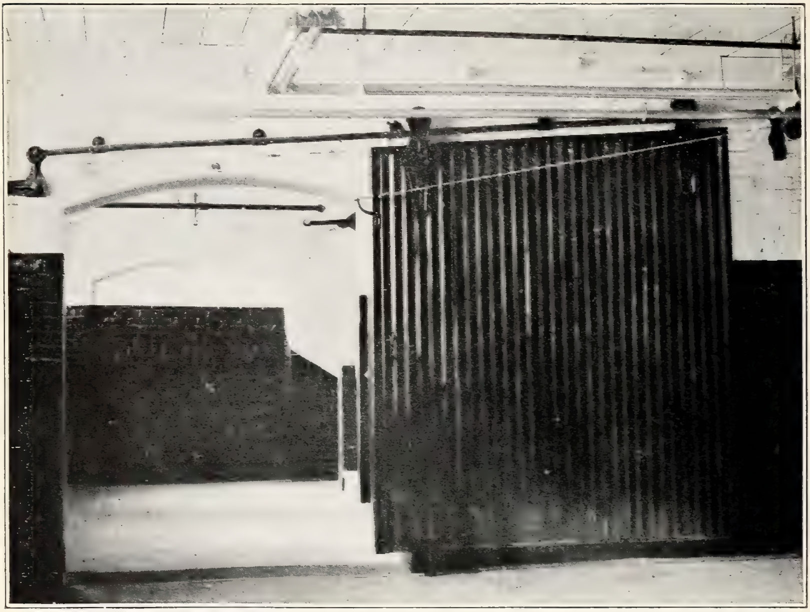


FIG. 1.—AUTOMATIC FIRE DOOR MADE OF CORRUGATED STEEL ON A FRAME OF ANGLE IRON.

This door is also suitable for the regular exterior door.

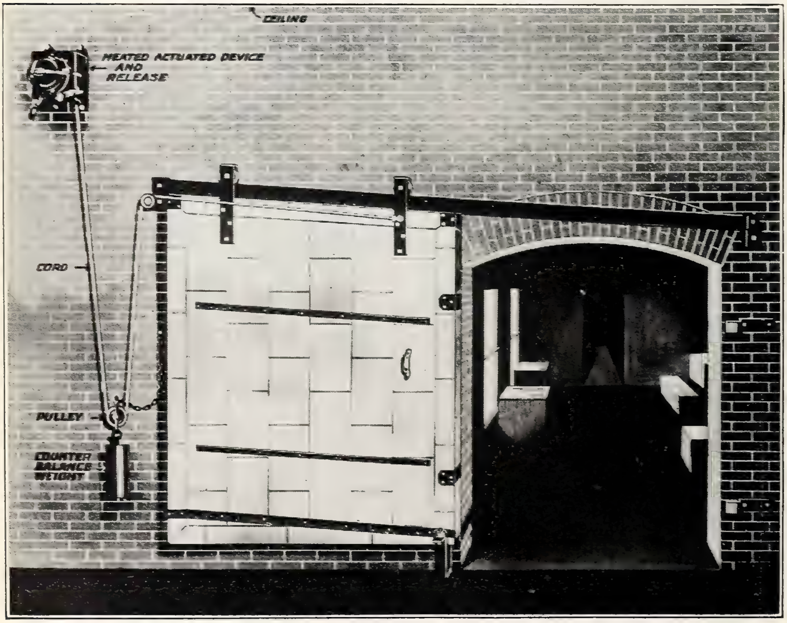


FIG. 2.—FIRE DOOR EQUIPPED WITH A SENSITIVE AUTOMATIC RELEASING DEVICE.

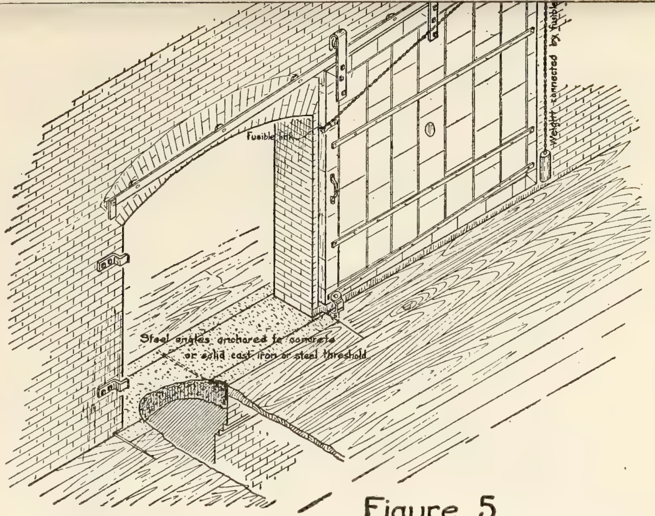

Fusible link
Weight connected by fusible
Steel angles anchored to concrete
or solid cast iron or steel threshold

Figure 5.

AUTOMATIC SLIDING FIRE DOOR INCLINED TRACK.

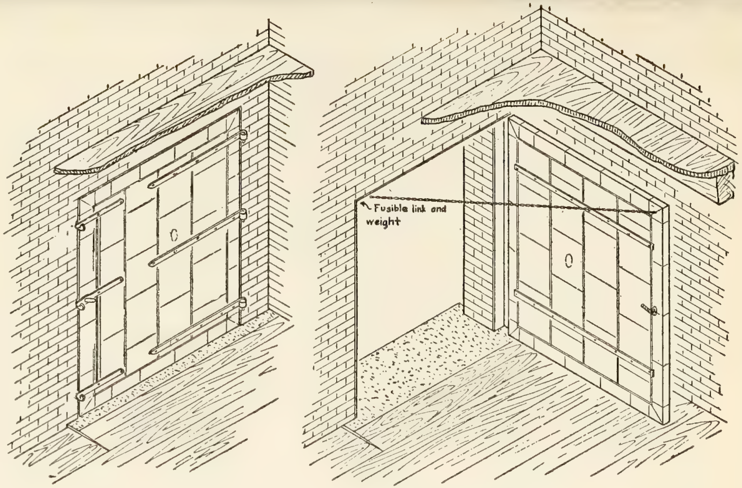
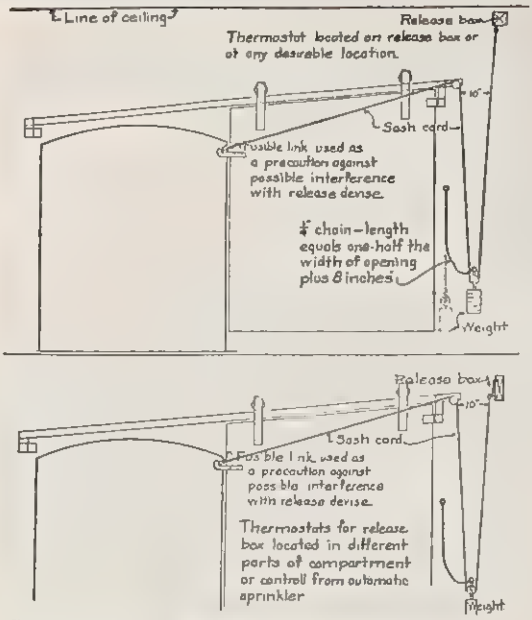
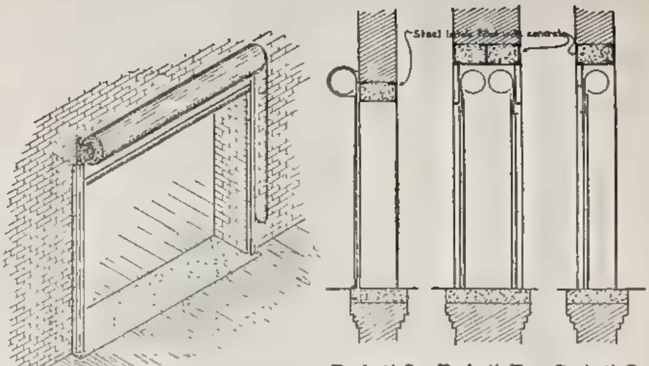


Figure 6.

AUTOMATIC SWING FIRE DOOR: MAY BE ARRANGED FOR SELF CLOSING.


Line of ceiling
Release box
Thermostat located on release box or at any desirable location.
10"
Sash cord
Fusible link used as a precaution against possible interference with release devise.
¼" chain–length equals one-half the width of opening plus 8 inches
Weight
Release box
10"
Sash cord
Fusible link used as a precaution against possible interference with release devise.
Thermostats for release box located in different parts of compartment or controll from automatic sprinkler
Weight

DIAGRAMS SHOWING METHODS OF INSTALLING SENSITIVE RELEASE BOX-THERMOSTAT CONTROLL.



Detail A. Detail B. Detail C.

Figure 2. METHODS OF INSTALLATION

STEEL ROLLING FIRE DOOR MAY BE AUTOMATIC, HAND-OPERATED, OR BOTH COMBINED.

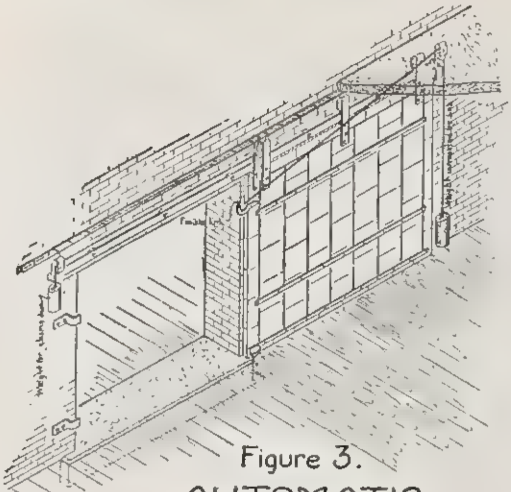


Figure 3.

AUTOMATIC SLIDING FIRE DOOR-WEIGHTED.

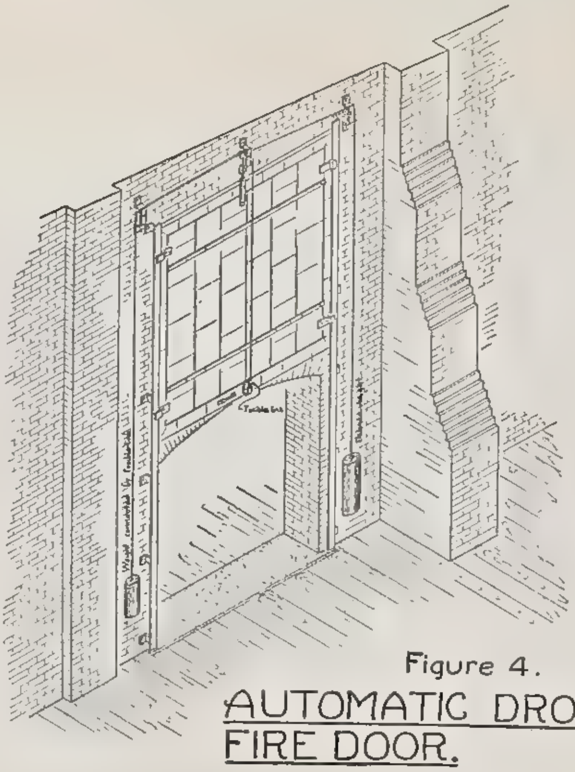


Figure 4.

AUTOMATIC DROP FIRE DOOR.

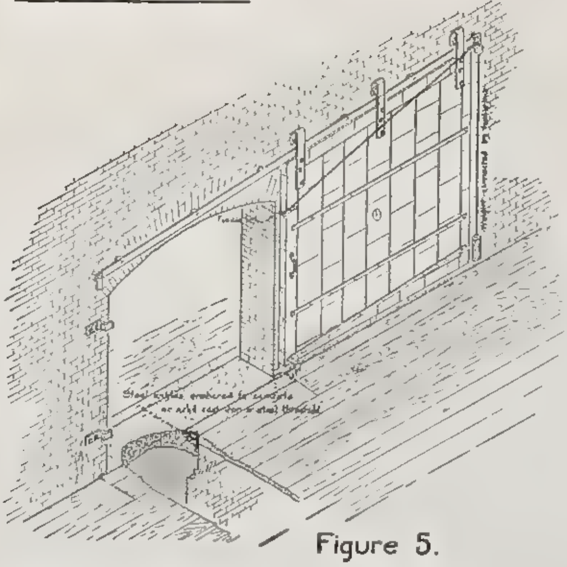

Fusible link
Steel angles anchored in concrete or solid cast iron or steel threshold

Figure 5.

AUTOMATIC SLIDING FIRE DOOR INCLINED TRACK.

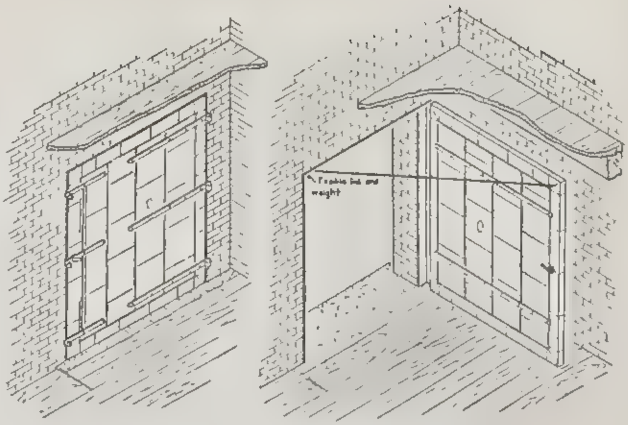


Figure 6.

AUTOMATIC SWING FIRE DOOR: MAY BE ARRANGED FOR SELF CLOSING.

Doors in the exterior wall may be of several different types. In most instances the sliding door is to be preferred as it is easy to operate and may be fitted close to the wall. An excellent door of this type is shown in Plate XIII, figure 2. Here the door is composed of three layers of wood covered with tin so as to resist the action of fire from either side. The hardware should be such as to hold the door closed even after long exposure to fire. For this reason all hinges, track supports, and other hardware should be built solidly into the wall. Whether or not doors are locked is a question for the management to decide. Rolling steel doors which slide, or roll up, may be used to good advantage where it is desired to provide openings near together as for a compress. These doors are extremely neat and resist fire well. They have one serious disadvantage for the storage compartment in that they are difficult of operation from the outside, and it is necessary for the person operating them in this way to stand in the opening until the door is entirely raised. The difficulty here in case smoke or flame had to be contended with is apparent. But for the large compress compartment, with its entrance doors of some other type, these doors are excellent. Photographs of installations of these doors are shown in figure 1, Plate XIII. Swinging doors are usually less desirable than sliding doors as the former are somewhat in the way of trucking and are put out of repair more easily.

FIRE DOORS.

Fire doors in the division fire wall should afford high resistance to heat. The construction is similar to those described for the exterior wall, with the addition of requirements for automatic closing in case of fire. There are many types of fire doors which may be purchased ready to install. All of the doors illustrated by Plate XIV are what is termed "tin-clad" (a wood core covered with tin) except that shown in figure 2, this being a steel rolling door which may be installed in the several manners shown. This door is very neat in appearance and affords good protection. Doors of the sliding or hinged type are also made of sheet steel corrugated and riveted to a framework of steel as shown in Plate XV, figure 1. The tin-clad door referred to is an excellent door for an opening in a division fire wall. It should consist of three layers of boards, each not less than thirteen-sixteenths of an inch thick. The tin covering should be applied independently of the use of solder, the joints being securely locked and nailed. There are many details to be followed in the construction to insure the best resistance to fire and positive movement in closing.[1]

---

[1] The door can be built locally by a good tin worker and carpenter, or it can be bought ready made. The latter course may be more economical and is nearly

The size of the door should be no greater than necessary and in no case should it exceed 120 square feet in area of opening or 12 feet in width. It is preferable that the door opening be not wider than 10 feet. Doors of large size are not nearly as strong in their resistance to fire as smaller doors. Generally a door should be used on both sides of the wall so as to protect the opening against a long-sustained fire; this also gives greater certainty that at least one of the doors will close.

It is extremely important that a door which has closed from any cause be easy to open from either side, as this is a matter of protection to both life and property. If a door closes during a fire a person may be confined in the fire area, or, on the other hand, persons desiring access to the fire in order to extinguish it may be delayed by their effort to open the door.[2]

---

always the more satisfactory provided the purchase is confined to doors approved by the Underwriters' Laboratories. Insurance associations will furnish detailed specifications and explanatory drawings showing the construction of tin-clad doors, but, all too often, these are not followed by the mechanics.

The istallation of all types of fire doors should be such as to insure the holding of the door very securly against the wall and so the hardware (including the track for sliding door) should be extremely heavy and securely applied, since it may be exposed to a long-continued fire. Pieces of hardware attached to doors should be fastened with bolts or rivets extending entirely through the door, while parts applied to the wall should be bolted entirely through it. The door should overlap the wall 4 inches at both sides and top of the opening unless it closes properly into a recessed steel frame securely anchored to the wall. The joint formed at the floor should be close, the door closing upon a steel or iron or concrete threshold extending under it 6 inches.

[2] A variety of fire-door arrangements is shown by Plate XIV. Rolling steel doors with various methods of installation are shown in figure 2, Drawing I. "Detail A" shows an economical method which is satisfactory in most cases.

The sliding fire door is usually to be preferred, as its operation is easy and positive. The usual installation, shown by figure 5, provides an inclined track (having a slope of three-fourths or 1 inch per foot), which causes the door to roll shut by gravity when automatically freed from a restraining weight. This weight (shown to the right of the door) is suspended by a cord which passes over a pulley attached to the track or wall and thence to a bracket secured to the side of the door and projected beyond it and into the opening. The connection between this bracket and the cord is made by a "fusible link" which consists of two thin pieces of metal soldered together with solder, which melts at a temperature of 165° F. The action in case of fire is that this fusible link melts apart, thus disconnecting the restraining weight from the door, which rolls shut by its own weight acting upon the inclined track. The fusible link should be projected into the opening in order that the natural draft of heat through the door may melt the fusible solder as soon as possible.

In situations where the story height does not allow the necessary incline for the track, it may be installed level and the closing action of the door secured by an additional weight, as shown to the left of the opening in figure 3, Plate XIV. This second weight should be connected securely to the door by a substantial sash chain in order that it may hold the door shut during a

Fire doors for protection of openings in a division wall should always be arranged to close automatically in case of fire. The arrangement should be such that the door is held open, against its tendency to close from gravity, by a device which is affected by heat in such manner as to release the door and permit it to close in case of fire. The arrangement may be such that the door normally is closed but may be held open by a special hook designed to release the door should fire occur. All self-closing doors should provide this automatic combination, as otherwise there is danger of the door being purposely obstructed and then overlooked until a serious fire loss has supplied a costly reminder.

---

fire. The pulley over which the chain passes must be sufficiently high to insure that the door is entirely closed before the weight reaches the floor. The weights used for holding open either type of sliding door (shown to the right of the doors) should be adjusted to balance the door exactly and so allow it to be closed by hand. The self-closing feature may be added to both of these doors by omitting the weights which hold the door open. When this is done the fusible link should be retained and a hook provided to secure it to the edge of the opening when it is desired to hold the door open. Unless the link and hook are provided, doors should never be self-closing, as they frequently will be obstructed "temporarily" for the movement of goods and then forgotten. If the hook is provided, it will be used as the easiest way of holding the door open, and if the door is, by chance, left open it will still close automatically in case of fire. It should be noted that the hardware for these doors provides a roller at the bottom of the door for holding it close to the wall on one side, while the door is held firmly when closed by the heavy iron bumpers on the other side. These doors show three hangers, the center hanger serving to hold the door against buckling from heat. Two hangers are sufficient for doors not exceeding 6 feet in width, while three hangers are required for wider doors. Goods should never be piled again the door. To guard against this it is sometimes desirable that a substantial slatted guard be provided.

Drop doors, or those vertically sliding, such as is shown by figure 4, Plate XIV, may be used to advantage in case obstructions such as pilasters or buttresses interfere with the horizontally sliding door and where the height of story is sufficient. In the illustration the weight shown on the left is connected by a cord passed through two pulleys to the fusible link placed at the bottom edge of the door, and when the weight is released the door closes. The closing is made gradual by the large counter weight or balance shown on the right. This door may be operated by hand, though it is not opened as readily as the horizontal sliding door, and is particularly difficult to open after the closing has been automatic. Furthermore, it presents some hazard to life if it should drop while a person were passing under it, though this danger is reduced by the large counterweight.

The swinging door shown by figure 6, Plate XIV, is satisfactory though it is better suited to small than large openings It may be arranged to be self-closing or to close automatically, but care should be taken that the fusible link used is placed in position to be reached by drafts of air through the opening. For this door the hardware, unlike that of the sliding or drop doors, must provide substantial latches which will hold the door securely when closed.

RECENT AUTOMATIC DOOR CLOSERS.

Closing devices much more sensitive than the fusible link are now available for use on fire doors. The fusible link requires heating of the solder and surrounding metal to a temperature above 165° F. The length of time required depends on the intensity of the heat at the door which may be placed some distance from the origin of the fire, or subject to conditions which would allow the fire to spread through the opening before closing action of the door. The improved closing devices either provide heat detectors at intervals over the ceiling or provide near the door a single heat detector which responds to a sudden rise of temperature.

As an example of these principles, there is a device which is provided with a heat detector which closes the door to which it is connected when the temperature rises more rapidly than is occasioned by weather or working changes. It is not necessary that the heat reach any fixed temperature, but simply that there be a sudden rise of temperature at the location of the heat detector which may be at the door or a distance from it, or there may be several detectors provided at different places. These detectors may be installed on both sides of the division wall and operate a door on either or both sides, the releasing mechanism usually being on the wall and near the door. The heat detector is connected with the door-releasing mechanism by an air tube and the motive power is supplied by the rate of rise in temperature at the location of any of the detectors. Such a device is extremely sensitive to heat, even though the source of the heat be in a distant part of the compartment. No connections of any kind independent of it are required and no electricity is used.

Another instance of a sensitive door closer is a device based, not as the first on relative change of temperature, but on response to a fixed temperature exceeding 165° F. with means of detecting such temperature placed in different parts of the compartment. This is accomplished by a device which makes an electrical connection when the given temperature is reached. With this system, electrical current may be taken from any constant supply or from a storage battery or both. Unless the installation provides an alarm system which will indicate interruption in supply of current the battery should be used. This device also supplies an automatic fire alarm. It may be connected to the sprinkler system so that when this is called into play all fire doors will be closed.

The new and improved door-closing devices are establishing a good record, but it must be remembered that the simple fusible link has given positive service and a reasonable degree of protection for many years. It is unwise to discard this simple link, but it is desirable that it be supplemented by one of the more sensitive devices if the values of the risk are large and in all cases if the cost is not great. The owner should remember that a division wall loses much of its value if it contains openings not adequately protected and that protection of these openings demands not only that the door resist the action of heat when closed but that it close promptly.

An essential for the satisfactory operation of a fire door is that it be in good order at the time of the fire. Spread of fire through the opening can generally be traced to the fact that the door was out of repair or was obstructed by goods. Therefore doors should be examined and operated by hand frequently and closing devices other than the fusible link should be tested. The examination of the door should be such as to determine whether or not it would close when automatically released, as in case of fire. For example, the sliding door should have its restraining weight lifted gently, care being taken to see that the door moves promptly and closes entirely. Door and track must be unobstructed and rollers must move freely and without binding of the door.

FLOOR DIRECTLY ON EARTH.

The first or ground floor of the compartment (and this is frequently the only floor) may rest directly on the ground, which is decidedly the most economical arrangement in most cases. The material should not be combustible, though treated wood-block paving is not objectionable and is an excellent material for the compress floor. Cement pavement usually gives the best results for such a floor, as it may be trucked over with ease, does not deteriorate with time, and is economical in cost of construction. The chief precaution to be taken in its use is to insure freedom from moisture and consequent damage to the cotton stored directly on the pavement. Where the surface of the floor is a foot or more above the ground on all sides, the site well drained and the soil not excessively wet, no trouble is likely to be experienced, but in less favorable situations special methods must be resorted to in order to prevent the penetration of water. This may be accomplished in almost any situation by proper construction of the floor.[1]

---

[1] The cement floor for such locations as do not present serious danger of water seeping through the floor may be laid continuously and without joints except for those that may be caused from a stoppage of work, as from evening until morning. Here the work should be stopped off evenly so as to form a square or right angle, vertical joint with the new work. In cases where there is any danger of water seepage, the floor should be laid in squares with joints between formed every 4 to 6 feet by tar paper, prepared to form a thickness of about one-fourth inch, which permits the floor to expand and contract without forming irregular cracks and at the same time forms a joint which is waterproof.

The pavement preferably should consist of a rough slab of concrete 3 or 4 inches thick, composed of 1 part Portland cement, one-seventh part hydrated

There are many waterproofing compounds on the market which afford various degrees of protection. Those used for concrete usually are designed to be mixed with the water used in preparation of the mortar, whereas some may be used as a brush application to the finished surface. While some of these preparations justify the claim as waterproofing, the prospective purchaser will do well to make thorough inquiry before investing in them.[2]

---

lime, 3 parts sand, 6 parts crushed stone (or such amount as may be used with confidence that all voids are thoroughly filled by the mortar—that is, the sand and cement mixture) with water to form a fairly wet mixture. This should be finished on top by a mortar composed of 1 part Portland cement, one-seventh part hydrated lime, 2 parts sand, with water to form a freely working wet mortar. The concrete should be deposited on firmly packed earth and tamped until thoroughly packed with water showing on top. The top-dressing of mortar should be applied as soon as the concrete is packed. Increased resistance to the passage of water from the ground is given by a very dense mixture, such as is secured with a liberal amount of water for mixing and also by the addition of the small quantity of hydrated lime. Sand, for the best results, should be of a mixture of fine and coarse grains, with predominance of the coarse. Under any conditions resistance to the passage of water is increased as the proportion of Portland cement used is greater. (See United States Bureau of Standards, Technical Paper No. 3: Tests of the Absorptive and Permeable Properties of Portland Cement Mortars and Concrete, Together with Tests of Dampproofing and Waterproofing Compounds and Materials, by Rudolph J. Wig and P. H. Bates. 1911.) The top dressing of the richer mixture also supplies a hard, smooth surface which is not readily chipped by truck wheels.

If conditions of the site warrant full protection against water, better protection is secured by interposing between the layer of concrete and the top-dressing, a layer of very pliable tarred roofing felt. The edges of the widths should be fully lapped and cemented by tar and pitch. Where this is done the concrete slab must first be allowed to set and the top-dressing should be 2 or 3 inches thick, while the concrete slab may be reduced to the same thickness. If the top-dressing is too thin and separated from the concrete, it is likely to buckle and crack. The expansion joint of tar paper in this case need extend through the top-dressing only. Still better protection is afforded by a thorough coating of hot tar or tar and pitch applied to the rough slab before the application of the top-dressing, but after the rough slab is dry. In this case the top-dressing need be only 1 inch thick. The expansion joints in this instance should extend through both the rough slab and the top-dressing. The latter method of retarding water is to be preferred, provided care is exercised to see that all parts of the surface are well covered with the tar. Where work is done carelessly the first method usually will be more satisfactory. Either arrangement affords adequate protection. However, for all favorable conditions such precautions are unnecessary.

[2] See United States Bureau of Standards, Technical Paper No. 3: Tests of the Absorptive and Permeable Properties of Portland Cement Mortars and Concrete, Together with Tests of Dampproofing and Waterproofing Compounds and Materials, by Rudolph J. Wig and P. H. Bates, 1911.

A satisfactory substitute for the waterproofing methods described (and a plan which well may be combined with these for unusually trying conditions) is

For most conditions a floor sufficiently dry will be secured by use of the simple concrete pavement first described, provided the proportion of cement stated is not reduced, the sand is not excessively coarse, the stone is of proper size to insure no voids being left open, and reasonable care is exercised in mixing and placing the material.

Floors consisting of a concrete made of a mixture of tar, sand, and crushed stone with thick plank embedded upon this layer and the surface finished with regular hardwood flooring have been used with excellent results. The only objection to this construction is the excessive cost, which is prohibitive for the usual warehouse.

Boards of 2 to 3 inches in thickness may be used laid flat on the ground and nailed to skids 4 inches square bedded in the earth. In this case the timber should be heart pine or oak. Sap pine may be used if air-dried and thoroughly treated with creosote to retard decay. Both of these last forms of floor construction are fairly satisfactory from a fire-hazard standpoint, though they are not as desirable as a strictly non-combustible floor such as is afforded by concrete.

Earth, shell, or cinder floors may be used in some sections of the country where no damage to the cotton from moisture will occur. As a safeguard, however, it usually will be necessary to raise the cotton a few inches above this surface by means of wood strips or stringers. Such floors make trucking extremely difficult and generally should be avoided.

Upper floors of warehouses several stories in height, should be of fire-resistive construction presently to be described. Where there is but one floor and the ground is very rolling, there is a temptation to use heavy frame construction. This should not be done, as such construction reduces the protection against fire very much as far as that compartment is concerned.

Floors of any material and for any conditions, whether there be one floor or several stories, should be constructed with a slight incline from the center of the compartment toward the exterior wall in order that water used in case of fire may drain off readily through wall openings or scuppers provided. This slope should be a total of about

---

a system of underdraining of the floor. This may be accomplished by placing 1 foot or more below the floor, a line of open joint field tile, the lines being spaced at intervals of from 25 to 50 feet. The trench in which the tile is laid should be filled with crushed stone, gravel, broken brick or coarse cinders, while still better results are secured when the use of this material is extended to form a layer about 2 inches thick under the floor. The lines of tile should be given sufficient grade or fall to drain off and discharge water finding its way into them.

6 inches in 50 feet, the usual amount for the compartment 100 feet in length between exterior walls. This slope will reduce damage to the cotton and, in the case of elevated floors, will prevent possible overloading from an accumulation of water—such as might result from continued flow of sprinklers.

ROOF AND SELF-SUPPORTING FLOORS.

Designs and materials for fire-resistive roofs and self-supporting floors have been tried in many forms. Many methods of construction used in the early development of fire-resistive construction were needlessly costly and afforded very poor protection. In fact, the simplest and often comparatively inexpensive construction usually has proven the best.[1] This discussion of roof and floor designs will be confined to constructions which is most suitable for the warehouse. For special conditions other types of construction possibly may be suitable.

Reinforced concrete is preeminently suited for the requirements of the cotton warehouse. This material consists of concrete composed of Portland cement, sand, and crushed stone or similar material, so strengthened or reinforced with steel rods as to secure the most economical use of the strength and fire-resistive qualities of both materials.[2]

In this construction the tensile strength, or the capability to withstand a pulling force, is supplied by the steel rods which are protected from the action of fire by the surrounding concrete. The compressive strength, or the capability to withstand a pushing force, is supplied by the concrete. This action of the concrete is sometimes supplemented by additional steel. The value of this construction depends very largely on a proper proportionment and arrangement of the concrete and the steel. A detailed discussion of the engineering phase of the construction is scarcely within the scope of this treatise, though it should be pointed out emphatically that the design should be handled by a competent engineer experienced in this character of work, while the construction should be under careful supervision. The most dangerous construction has been the result of builders having no knowledge of the real principles of engineering involved. The mere judgment of such builders is worthless in this type of construction, even though they may be successful in ordinary frame buildings.

---

[1] Valuable information and result of fire tests is contained in a Report on a Test of Floors in the United States, by Ira H. Woolson, E. M., consulting engineer, National Board of Fire Underwriters and Rudolph P. Miller, C. E., superintendent of buildings, New York City.

[2] See U. S. Bureau of Standards, Technologic Paper No. 2: The Strength of Reinforced Concrete Beams; Results of Tests of 333 Beams, by Richard L. Humphrey and Louis H. Losse, 1911.

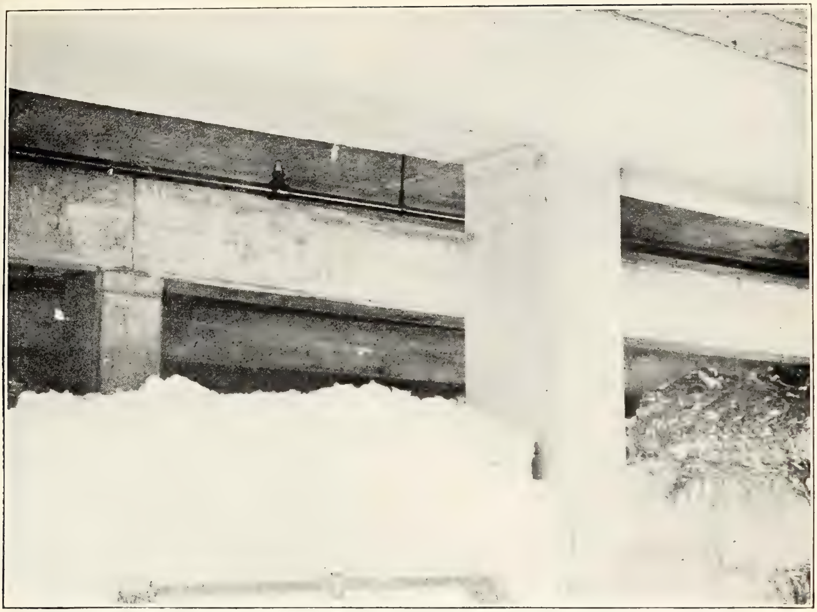


FIG. 1.—CEILING SHOWING A REINFORCED CONCRETE FLOOR ABOVE.

Note the arrangement of sprinkler piping.

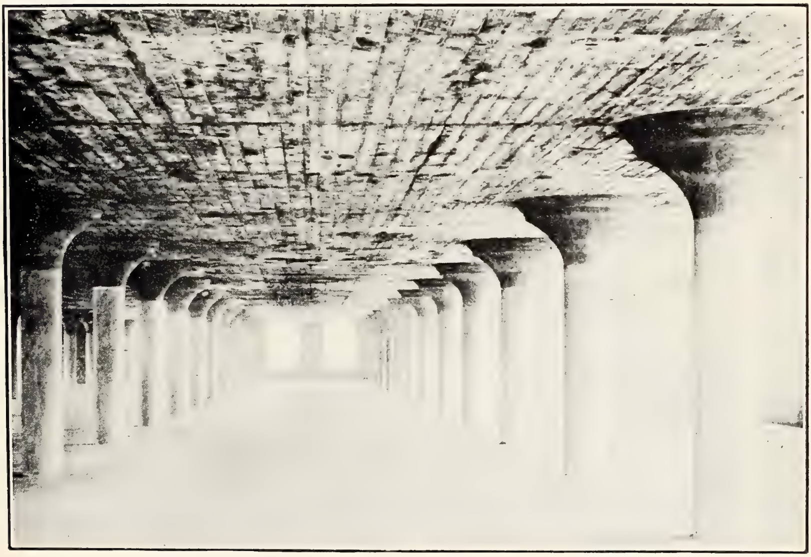


FIG. 2.—INTERIOR VIEW OF A FLAT SLAB DESIGN OF REINFORCED CONCRETE.

Note the unbroken surface of the ceiling so advantageous in the diffusion of light and well adapted to deflection of water from hose stream and sprinklers.

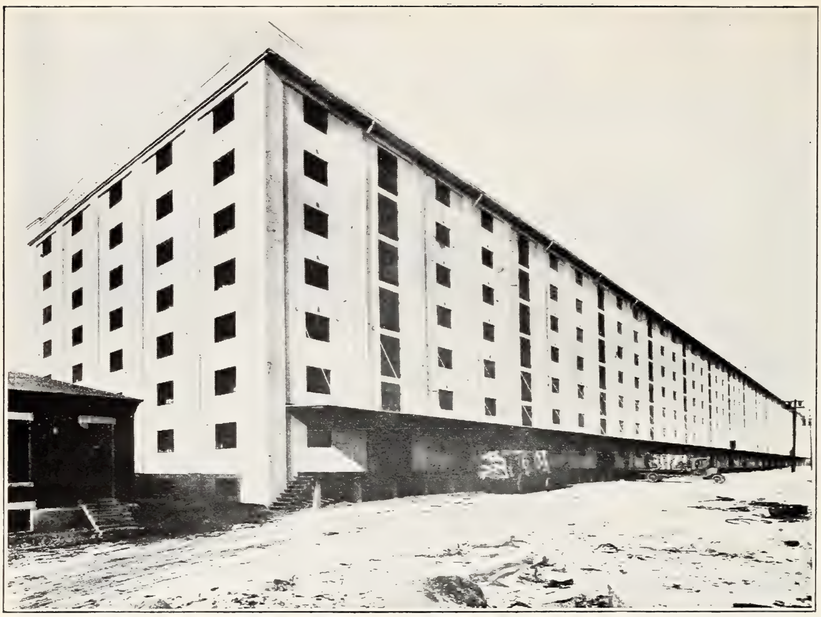


FIG. 1.—VIEW OF A REINFORCED CONCRETE WAREHOUSE OF A DESIGN SUITABLE FOR A GREATLY CONGESTED SITE.

Platforms for each floor should always be provided on one side of such a building and doors on the other side, as shown.

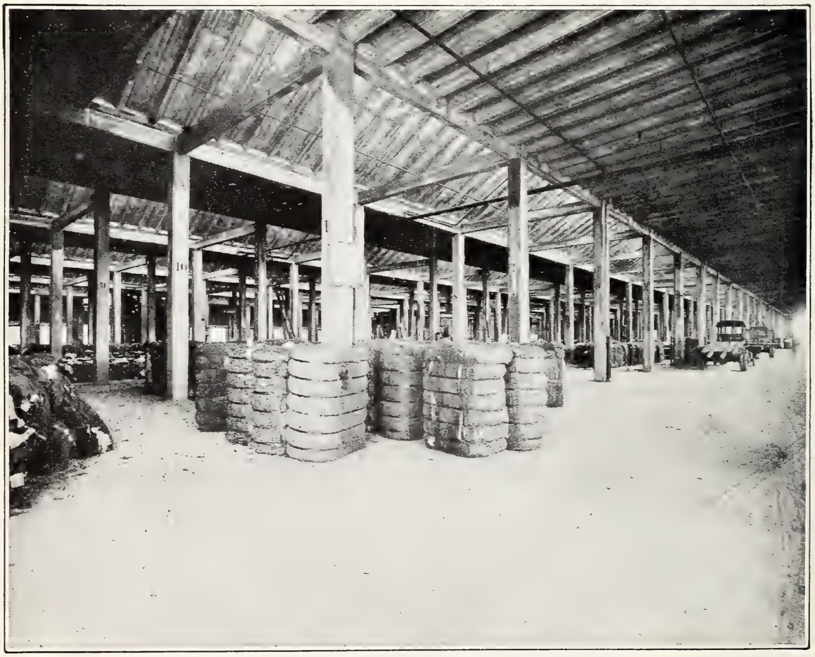


FIG. 2.—INTERIOR OF A REINFORCED CONCRETE COMPRESS COMPARTMENT.

Note the excellent light supplied by the saw-tooth skylights.

PLATE XVIII.

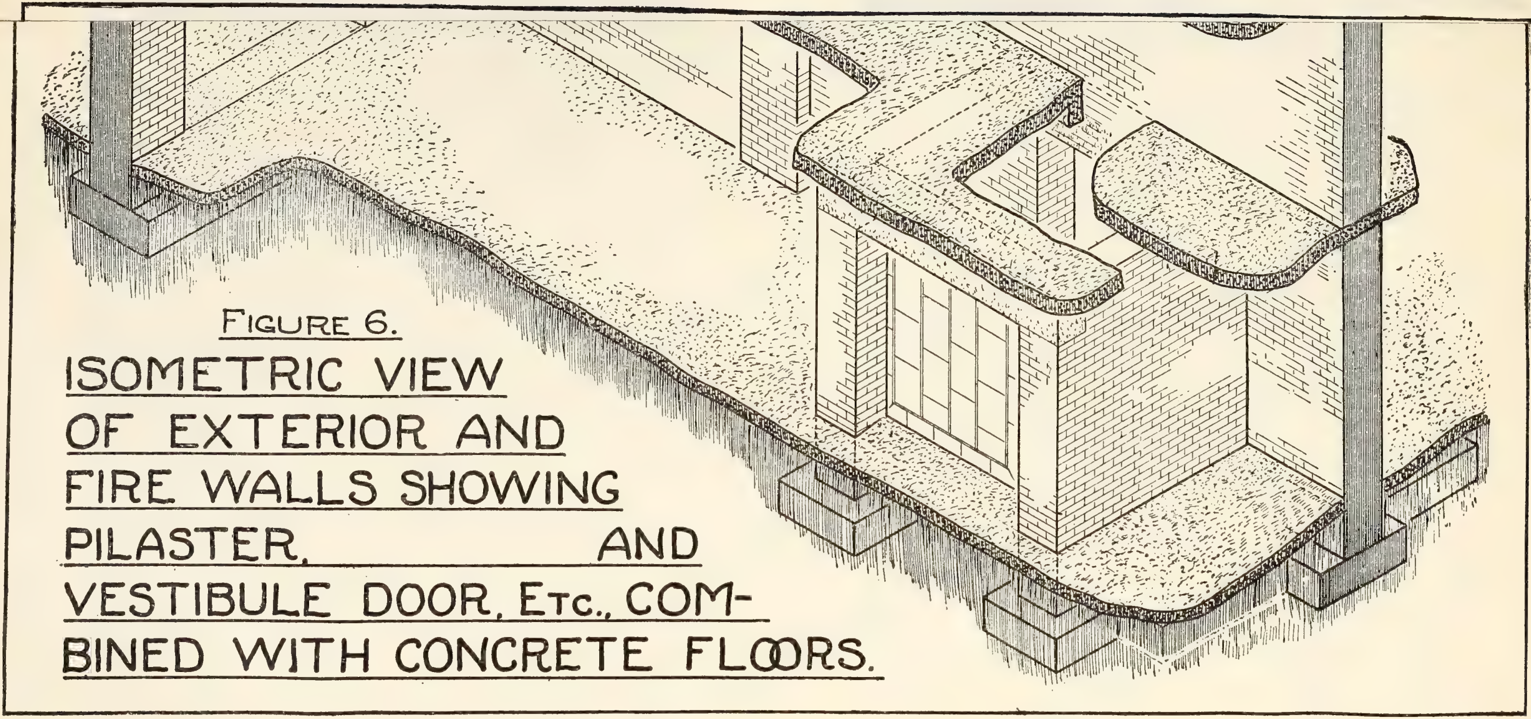


FIGURE 6.

ISOMETRIC VIEW OF EXTERIOR AND FIRE WALLS SHOWING PILASTER, AND VESTIBULE DOOR, ETC., COMBINED WITH CONCRETE FLOORS.

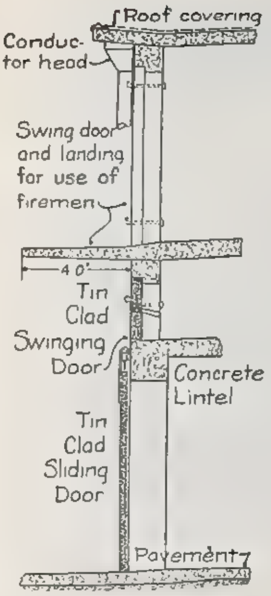


FIGURE 1.
EXTERIOR WALL.

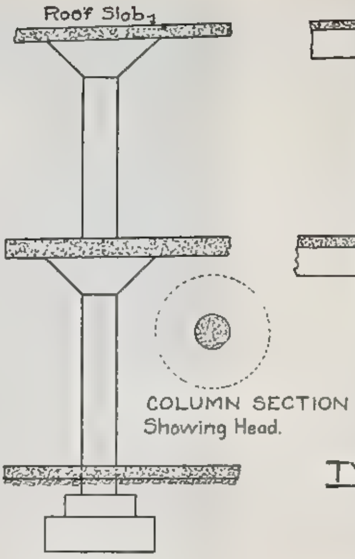


FIGURE 2.
FLAT SLAB FLOOR DESIGN.

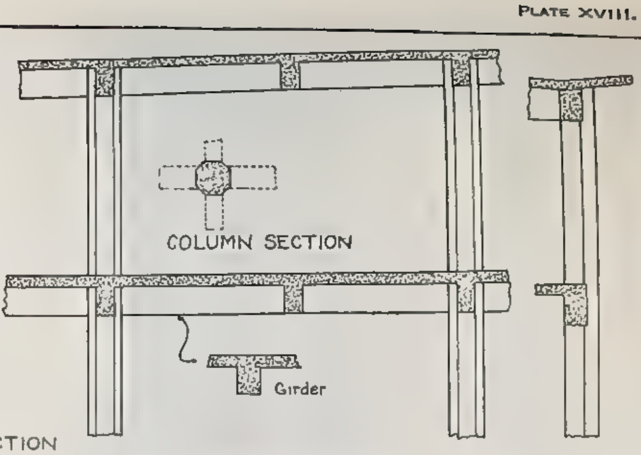
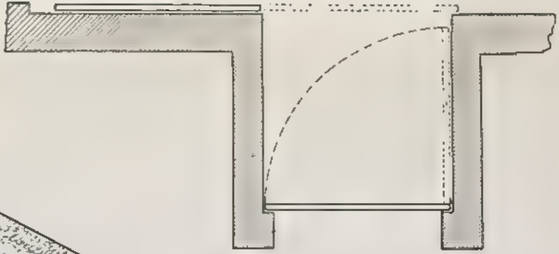


FIGURE 3. FIGURE 4.
TYPICAL BEAM-SYSTEM DESIGN.

FIGURE 5.
PLAN OF VESTIBULE FOR SLIDING & SWINGING DOORS.



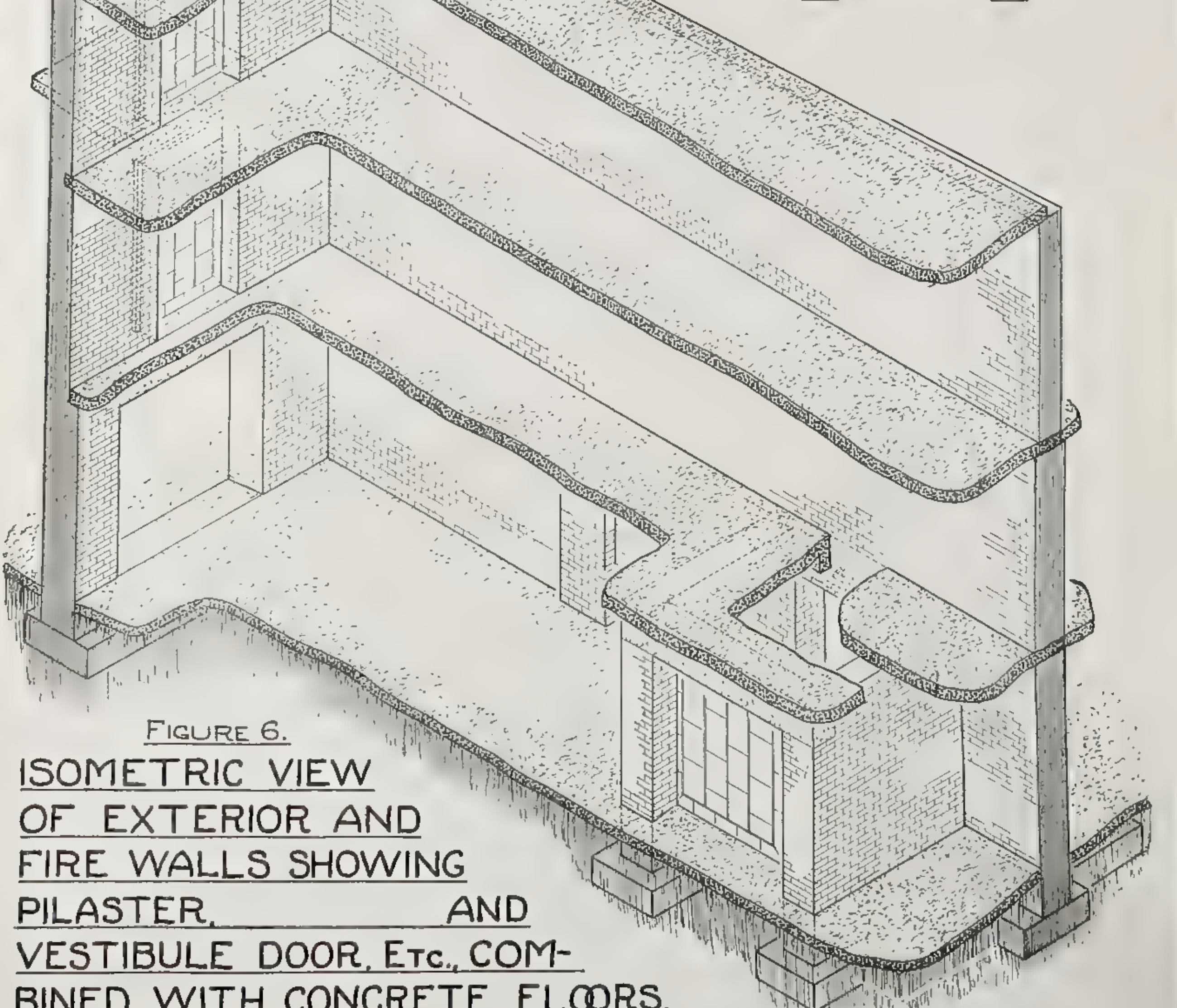


FIGURE 6.
ISOMETRIC VIEW OF EXTERIOR AND FIRE WALLS SHOWING PILASTER, AND VESTIBULE DOOR, ETC., COMBINED WITH CONCRETE FLOORS.

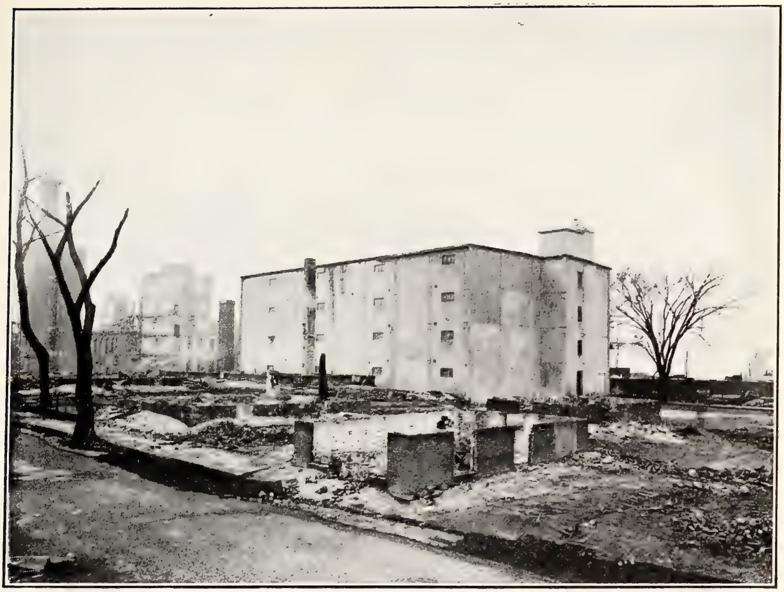


FIG. 1.—WAREHOUSE WHICH SUCCESSFULLY WITHSTOOD SEVERE FIRE TEST.

View shows exterior practically undamaged, although surrounding buildings were destroyed.

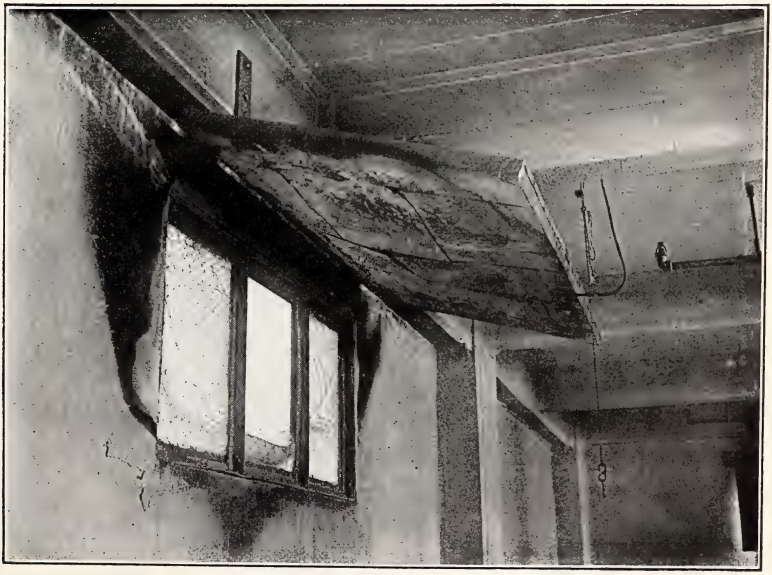


FIG. 2.—INTERIOR VIEW OF ABOVE WAREHOUSE.

Note complete protection afforded by tin-clad fire shutter.

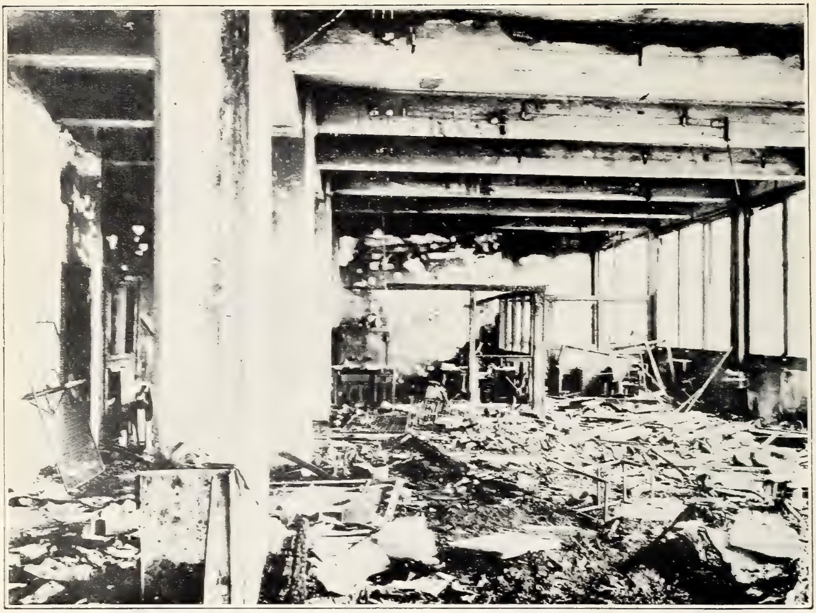


FIG. 1.—INTERIOR OF A REINFORCED CONCRETE BUILDING UNDAMAGED AFTER THE CONTENTS WAS DESTROYED BY FIRE.

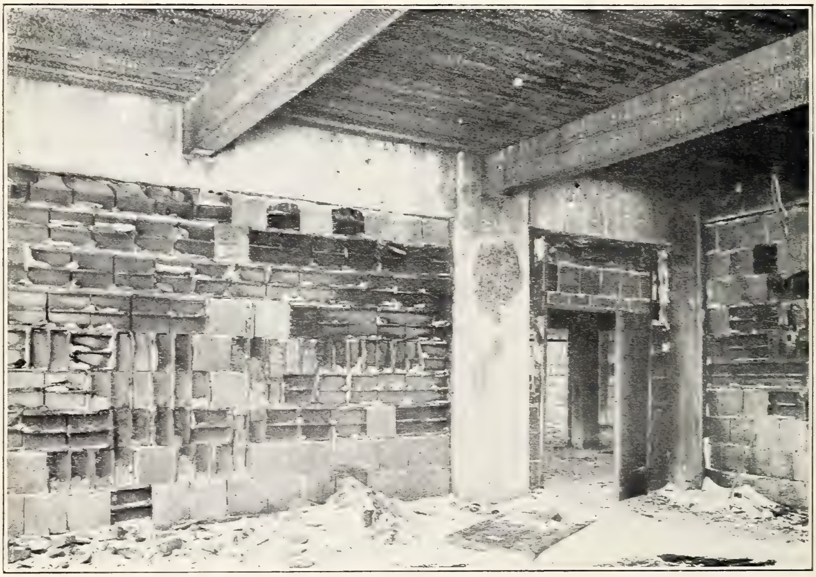


FIG. 2.—A HOLLOW-TILE PANEL WALL AFTER FIRE.

Note that while the tile is badly damaged the ceiling and floor planks are merely charred.

The various types of reinforced concrete floor and roof construction suitable for the warehouse may be considered as the flat slab, consisting of a thick slab supported by columns having large flaring heads, or capitals; the beam system, consisting of beams at intervals supporting relatively thin slabs of concrete between; and a combination of concrete beams and hollow tile in which the slab between main beams is really composed of a series of concrete beams, or joists, separated by a row of hollow clay tile.

The flat-slab system of construction is shown by Plate XVI, figure 2. The exact size and shape of the head of the columns vary with different designs and conditions. The flat ceiling shows freedom from obstructing beams. This permits a minimum height of story, the placing of sprinkler piping close to the ceiling, the most even distribution of light and, in case of fire, the most effective use of water from hose streams. The details of this construction as compared with the beam system is shown by Plate XVIII, figures 2 and 3. The flat slab designs are patented. The proprietors supply plans for their use and either make a charge for this or require the privilege of supplying material for use or actually doing the construction. This type of construction frequently can be used at a material saving over the ordinary beam designs. Unfortunately, there are some limitations to the economical use of flat slab designs for some cotton warehouses. These systems are the most economical when the floor or roof is continuous, the spacing of columns is nearly uniform in both directions, and the load to be carried is heavy.[1]

---

[1] These facts may be made more clear by reference to the accompanying plans. The design shown by figure 3 having compartments 40 feet wide with a single line of columns dividing the floor slab into spans—or distances between supports—of 20 feet is admirably suited for a flat slab design provided the division wall is made of reinforced concrete properly designed in relation to the floor or is a panel wall consisting of a concrete frame with panels built of brick or concrete such as was described under discussion of division walls. But if the wall is of any other design, such as brickwork, the flat slab system will not be economical from this standpoint. The spacing of columns in this case is 20 feet from the walls and 16 feet apart, which is satisfactory for the beam construction indicated, though fully as economical results for the flat slab systems would be given by increasing the spacing of 16 feet to 20 feet. The spacing of columns shown is especially economical for the beam design indicated. This plan shows a story height of about 13 feet, which contemplates the storing of cotton two bales high on end, which would result in a floor load of about 100 to 150 pounds per square foot. The flat slab design shows up to good advantage for these and heavier loads, the relative economy of the design being increased as the load becomes heavier. Roofs of this latter design may be used to excellent advantage for the compress compartment, such as is shown by figure 5. Here the spacing of columns 25 feet apart in both directions, with the smooth and unobstructed ceiling, is very desirable.

The ordinary beam system of reinforced concrete design is illustrated by the photograph, Plate XVI, which shows the interior of a compartment similar to those of the warehouse design in figure 2. In this last design the distance between the line of columns and the division wall is 25 feet, the compartment being 50 feet wide. The story height is 8½ feet, which permits the storage of cotton to a height of only one bale on end, and consequently a limitation in load of from 50 to 75 pounds per square foot. This extremely light floor load in combination with the rather long span of 25 feet between the column and wall are distinctly favorable to the beam system of construction.[1]

The combination of clay tile with reinforced concrete has not the advantages for warehouse construction that it has in ordinary domestic building. Its only advantage for the warehouse is that of reducing the amount of concrete and steel required for a given strength of floor or roof. In the case of the most economical design for the warehouse floor there is no advantage in the use of tile.[2]

FAILURE OF POORLY CONSTRUCTED FLOORS AND ROOFS FROM FIRE.

It is interesting to note the degree of success with which the types of construction here described have withstood the tests of fire. A view of a building which successfully withstood one of the

---

[1] In this instance the columns are located under alternate beams, while the intervening beam is carried by a cross beam, or girder. The beams are spaced 8 feet apart, which is a very effective spacing with this light load, considering the proportions necessary for both the beam and slab. The best fire resistance for beams is secured when the beam is no thinner than necessary, a good proportion being secured when the breadth, or thickness, of the beam is not more than half the drop, or distance from the bottom of the slab to the bottom of the beam; but in no case should the thickness of the beam be less than 6 inches, while 8 inches is to be preferred as a minimum thickness.

[2] For the roof slab, economy may sometimes be effected by the use of the tile, depending entirely on the local cost of materials. When it is used the blocks should be arranged end to end in a single row and with a space between rows of not less than 6 inches for the concrete joists, which are cast between. The whole top surface should be troweled over with cement mortar after casting to receive the roofing material. Even with the best of workmanship this construction is not as good as solid concrete, and the chances of poor workmanship are much greater than with the latter. Only a substantial saving in cost would justify a departure from the solid concrete for this particular character of building. The semi-porous clay tile is best for this use.

For all of these designs, columns should receive very careful attention. They may be round, octagonal, or square. The round is the best shape, but usually requires the use of metal forms. The octagonal shape is practically as good and is readily secured by use of wooden forms. The square column, most severe fires—the conflagration of Salem, Mass.—is shown in Plate XIX, figure 1. This view shows the exterior of the building practically undamaged after the surrounding buildings had been destroyed. The interior view (fig. 2 of the same plate) shows the complete protection afforded by the tin-clad fire shutter. The interior of another building which withstood the test, though the contents were entirely consumed, is shown in Plate XX, figure 1. Some idea of the effect of fire on hollow clay tile may be gained by an examination of Plate XX, figure 2. Here the fire wall is of the panel-wall type previously described, the tile panels being carried in a frame of reinforced concrete. The timber and plank floors of this building were only slightly charred by the fire which shattered the tile as illustrated.

SOME DETAILS OF CONSTRUCTION.

Emphasis should be given to the previous statement that the designing should be done by a competent engineer. Reliable engineering service is frequently supplied by proprietors of the patented systems, but it is best to have the services of a disinterested engineer who is familiar with the character and cost of the local materials to be used.[1]

---

while entirely satisfactory for exterior use, as for platforms, is not the most desirable for use inside as the corners are readily damaged by severe fire or broken by trucks.

While concrete properly reinforced with steel is the best material for fire-resistance floors and roofs, it is true that there have been cases of poor design and workmanship which failed utterly, and there are isolated instances of substantial reinforced concrete structures being damaged by extremely severe and prolonged fire. These fires have shown that concrete should be cast solidly in place in such manner as to make the building, or large sections of it, one solid whole, or monolithic, structure. These tests have further demonstrated the necessity of so placing the steel that it will be well protected from heat by the surrounding concrete. Such observations have indicated that concrete floor slabs should have a protecting thickness of concrete for the steel of 1 inch, while this thickness should be 1½ inch for walls and beams and 2 inches for very heavy beams, or girders, and columns. If such protection is not provided, a severe fire is likely to result in the steel reinforcement becoming so heated as to stretch, causing serious damage to the structure.

Floors may extend through division fire walls provided the mechanical design is such as to make the floor on either side independently self-sustaining in case the floor on the other side of the wall is destroyed. The same construction may be applied to the roof slab. This involves some modification in arrangement of reinforcement, and in some cases additional material. These stresses which would arise only in an emergency may be computed on the basis of the elastic limit of the materials rather than with reference to the usual allowable stresses which should be used in computing the normal working load.

[1] Materials for concrete permit of wide variation. The proportions for concrete reinforced should usually be 1 part Portland cement, 2 parts sand, 4 parts stone, and water as required. The stone should be in small pieces

Reinforcement should consist of steel of medium hardness and for general use should be in the form of bars or rods, as they are adaptable alike for walls, columns, beams, and slabs. These bars may be of any suitable shape, of which there are a great variety on the market. The plain, round or square bars are entirely satisfactory for all ordinary sizes. Many companies make a specialty of supplying steel for this use; the rods may be had cut to the proper length and bent to the exact shape desired. Usually it is best to use regular stock lengths and do the bending locally. A very simple bending machine for hand operation may be had for this work. Reinforcement for use in the slab may consist in whole or in part of woven-wire reinforcing

---

not over 2 inches in diameter, and preferably should be of varying sizes, ranging from 1½ inches down. It may consist of hard stone, such as trap rock, granite, limestone, and aggregates which are hard and do not decompose when subjected to severe heat. (The U. S. Bureau of Standards may supply reports, at a very small charge, on materials submitted.) The sand should be clean and free from loam, clay, or organic matter. The grains should be fairly coarse or a mixture of fine and coarse with the coarse grains predominating. The Portland cement should be of a good quality. While analytic tests have been fixed as a required standard (see U. S. Bureau of Standards Circular No. 33, United States Government Specification for Portland Cement, 1912; also Standard Test Specifications for Portland Cement recommended by the American Society for Testing Materials), it is usually a safe policy to use a brand of cement which has been on the market and in satisfactory use for five years and is made by a reliable company. Water for mixing should be free from alkali or injurious salts in damaging qualities. (See U. S. Bureau of Standards Bulletin No. 12: Action of the Salts in Alkali Water and Sea Water on Cement.)

Slag from blast furnaces, if burned free from coal, may be used as the coarse aggregate for concrete. It makes a concrete which is light, fairly strong, and withstands fire well. However, there are but few localities where slag is available.

Crushed terra cotta, tile, or brick are good substitutes for crushed stone for concrete, provided the clay material is hard-burned and used properly. After crushing, the dust should be screened out and the crushed brick should be wet thoroughly before mixing, for if the material is used dry it will absorb too rapidly the water used in mixing the concrete. Care should be exercised to see that brick used are hard and well-burned and that they are free from mortar; otherwise the finished concrete will be unreliable in strength.

Gravel should not be used for concrete work which may be subjected to fire, as such use has been found exceedingly dangerous. The use of quartz gravel in the reinforced concrete of a warehouse at Far Rockaway, N. Y., caused serious damage from a fire of comparatively short duration. A detailed report of this fire, written by Mr. Ira H. Woolson, may be had from the National Board of Fire Underwriters, New York City. A valuable test of gravel as compared with other stone for concrete has been made by the Bureau of Standards and the results have been recorded in an illuminating way by Mr. Walter A. Hull. (See Proceedings American Concrete Institute, Vol. XIV, 1918.) There is no objection to gravel, however, for concrete paving and for footings of the foundation.

materials which frequently can be used to better advantage and are more easily kept in place while the concrete is being deposited. Punched sheet steel also may be used provided the metal is not too thin.[1]

Forms for reinforced concrete may be used with maximum economy in construction of the warehouse. The uniformity of requirements with the consequent duplication of units, or compartments, makes possible a very high degree of standardization in form work with the result that forms can be used over and over again. The usual construction is with forms built of wood, though forms of steel are coming into use. Steel forms for columns, particularly those with flaring heads used for flat-slab construction, are desirable. Steel forms are also in use for wall construction. For floor or roof slab and beams, wooden forms generally are used and fulfill every requirement. These should be constructed in units of such size as to permit easy movement for additional use. The slab forms should be made of ordinary matched flooring; the same material may be used for beams and columns, though for this use material 1½ or 2 inches thick and closely jointed is to be preferred. It is of primary importance that all form construction be very rigid and of sufficient strength to support the heavy wet concrete without distortion, as any disturbance of concrete during setting is a serious impairment to its strength.

The floor slab should be finished with 1 inch of top dressing mortar composed of the same material described for finishing the paved floor. In this case the hydrated lime may be omitted, if desired. The rough slab should be wet thoroughly before this mortar is applied to insure a good bond between the two. Only the rough slab thickness should be considered in calculating the strength of the floor or roof.[2]

---

[1] Reinforcement should not be painted, as this renders less effective the bond or "grip" of the surrounding concrete upon it. This objection also holds good in regard to excessively rusty metal. Particular caution should be exercised against the use of badly rusted wire or punched steel, as here the amount of surface, as compared with the sectional area is large, and hence a definite penetration of rust gives a correspondingly greater reduction of strength than would be true of the larger rods.

Mixing of concrete should be done very thoroughly, the best results being obtained by the use of a machine of the type known as the "batch mixer." Sand and cement should be mixed dry before the water is added. Mixing should not be done in freezing weather. The concrete should be placed as fast as it is mixed, and should be tamped thoroughly to secure a dense mass free from voids. Reinforcement should be placed and inspected in advance and should be well secured against displacement.

[2] The roof slab should be smoothed off carefully as casting is done, or else there should be added a top dressing of 1 part Portland cement to 4 or 5

ROOFING MATERIAL.

Roof-covering material for the roof slab should be suitable for application without nails and for application by roofing cement directly to the surface. The material should be enduring under exposure to the weather and not inflammable. Two types of roofing material which may be mentioned as illustrating these qualities and being well suited to the desirable flat roof of the warehouse are "tar and gravel" and asbestos composition built-up roofings. Materials for tar and gravel roofing are manufactured by a number of concerns, some of which, at a small charge, will supply some supervision of the work and inspection service at intervals with a guarantee against leakage for 20 years. Where such an arrangement is not made, the owner should require the roofing contractor to guarantee the roof against leakage for a period of 10 years. This roof is probably the most economical for the warehouse. Its use is limited to comparatively flat surfaces, the slope of which in no case should exceed 3 inches per foot and may be practically flat. The best slope for the warehouse roof from every standpoint is one-half inch per foot.[3]

---

parts of sand in order to provide an even surface for application of the roofing material. In some very dry climates it should be satisfactory to depend on the concrete slab to afford protection from water, but for ordinary conditions this is not desirable, as it is difficult to prevent such cracks and openings as will result from contraction and expansion and from poor workmanship. Great care necessary to overcome this would usually be more expensive than the use of roofing material.

[3] The tar and gravel roofing is composed of several layers, preferably five, of roofing felt (a fibrous material formed into a paper-like sheet by the use of a tar or bituminous binder), well covered on the top surface with tar pitch applied hot and overlaid with gravel. The first layer of paper should be cemented to the concrete surface of the roof by hot tar pitch while successive layers should be bound together in a similar manner. The final surface of tar-pitch mixture poured on roof binds the gravel covering to the surface, the gravel being spread in place while the tar is hot. The gravel serves as a protection to the tar against the heat of the sun. The gravel, slag, or crushed stone should be washed free from dirt and should be screened to a fairly uniform size, which should be from one-fourth to five-eighths inch in diameter. The value of such a roof depends very largely upon the reliability of the workman, as this is a case where workmanship counts as much as material.

Asbestos composition roofings also are suitable for cementing directly to the roof slab. They are laid in several cemented plies similar to the method for tar and gravel roof, but no protecting gravel covering is required. The slope of the roof may be flat or as great as desired. Here also the personal element of workmanship is a vital factor, some manufacturers allowing their product to be used only where it is to be applied by roofers licensed or employed by them. Such roofing is ordinarily more expensive than the tar and gravel roofing. The asbestos roofing also may be purchased under a guarantee for service.

ROOF OPENINGS—VENTILATORS AND SKYLIGHTS.

Openings in the roof such as are needed for ventilators and skylights are permissible, though generally it is desirable that the sizes should not exceed the minimum necessary. Ventilators should be of metal, so designed as to be proof against the entrance of sparks from the outside. A convenient size is the 12-inch or 18-inch diameter round type of ventilator, of which there are a number of styles on the market. The revolving cowl ventilators should be used for the compress compartment. They discharge an enormous amount of air, as they are not dependent on merely difference in temperature within and without but are actuated also by a slight breeze. Either type of ventilator may be combined with the skylight. Ventilation may be given by the arrangement of one or more sides of the skylight, as louvers, or with a slatted construction. In such case the slats should be made of sheet metal rigidly set at an angle of 45° or more with the horizontal and overlapping. Where ventilators of any type do not provide satisfactory baffles to prevent the entrance of sparks, the opening should have a screen of No. 16 wire woven and galvanized, with a mesh of not over three-eighths inch.

The skylight in any case should be of metal frame, glazed with one-quarter-inch wire glass—that is, glass having woven wire made in it. Such glass will retard the passage of fire for a considerable time, whereas the ordinary glass is soon shattered by the heat. Moreover, wire glass is less easily broken out and so affords better protection for the opening. The glass should be set securely in the metal frame and made water-tight.

Fire shutters for skylights and ventilators are not required, as the chief hazard is assumed as from within. The resistance to fire afforded by the arrangements described is sufficient to prevent a rapid circulation of air and consequent rapid growth of fire, thus affording the best opportunity for extinguishment by the automatic sprinkler or hand appliances. Should these fail, however, the use of hose streams will be facilitated by the opening of the skylight, thus creating a draft and relieving the doors to some extent from projecting flame. They also provide an opening for the injection of hose streams.[1]

---

[1] Excellent skylight frames can be made of galvanized sheet iron of No. 24 United States gauge. Both the monitor and saw-tooth types of skylight are well adapted for the compress section, while the smaller metal frame skylight is suitable for the storage compartment. Practical use generally demands that the large glass sections of the saw-tooth or monitor skylight of the compress compartment be arranged to open at times, though when this is done the arrangement should be such as to permit the opening to be protected by a wire screen as described for the ventilator. The skylight

PLATFORMS.

Platforms connected with the warehouse should be of concrete for the pavement directly on the ground, or reinforced concrete for platforms above the ground. The platform for the first floor would consist, in nearly all cases, of a paved area which would either rest directly on the ground or on an earth fill inclosed by a retaining wall. Such an arrangement is shown by the drawings in figure 1. In some cases the first-floor platform may be constructed more economically of reinforced concrete. For floor above the ground floor, platforms always should be constructed of reinforced concrete, the details of construction being the same as described for such floors. Illustrations for such platforms are shown by drawings in figures 2 and 3. The width of platforms is a variable factor, though 10 feet usually should be accepted as a minimum, as this gives convenient room for the passage of the ordinary hand trucks. Platforms used for loading or unloading cotton from cars should be 20 feet wide, if possible, since this will allow the placing of cotton in quantity on the outer half of the platform, and yet provide a clear space of 10 feet between such pile of cotton and the warehouse wall. In the design of the platforms to be used in loading cars, no columns should be placed at the edge of the platforms, otherwise freight cars must be "placed" accurately to avoid having a column block the car door. Good platform construction is shown by the plan for a compress compartment in figure 6 and the storage warehouse plan in figure 2. The practice of roofing platforms, while very convenient, is an expense which usually can not be justified except in the case of the compress compartment and such adjacent storage compartments as are used in conjunction with it. Here platforms usually should be covered.

---

for the storage compartment should be stationary, so as to be closed at all times. Skylights for the storage compartment should be only of such size and number as is necessary for convenient handling of cotton and reading of tags. A size of 4 to 6 feet square is very convenient, while the size usually should not exceed 64 square feet. The compress section, however, requires considerably more light and ventilation, and the different conditions do not permit of a fixed size for these openings.

The single panes of glass used for these skylights should be of such size as not to exceed an area of 1,728 square inches or a width of 18 inches, the thickness of the glass being at least one-quarter inch. This limit of width is desirable for all glass; that used in a nearly vertical position (making 80° or more with the horizontal), if subject to an exterior exposure, should be restricted further to 720 square inches area and 48 inches for the greatest dimension. An example of this last requirement is that of monitors near together on a fire-resistive roof and communicating with separate compartments. However, this condition seldom obtains and the first limit stated is generally satisfactory.

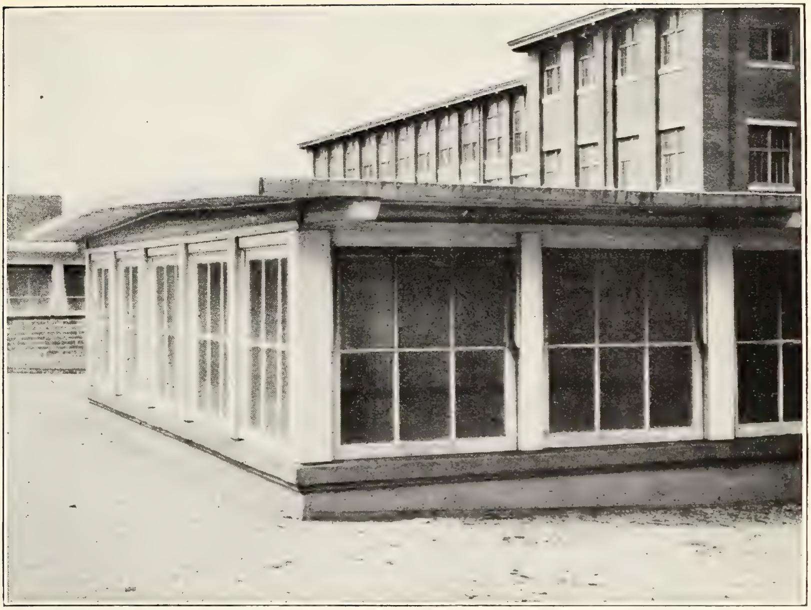


FIG. 1.—A MONITOR WHICH SERVES AS AN EXCELLENT SOURCE OF LIGHT AND VENTILATION FOR THE COMPRESS COMPARTMENT.

It should not be used within 50 feet of fire walls except when the monitor is of fire-resistive construction.

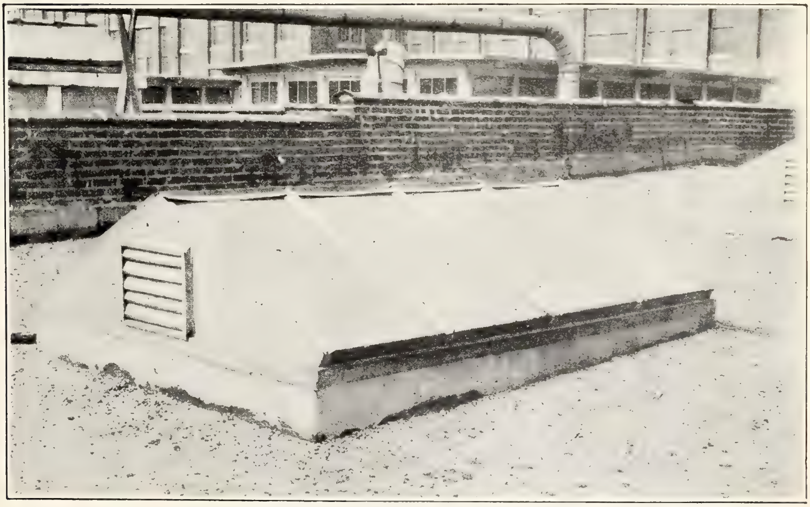


FIG. 2.—THE METAL FRAME SKYLIGHT AFFORDS ONE OF THE BEST MEANS OF LIGHTING THE STORAGE COMPARTMENT.

Note the ventilation provided in the end.

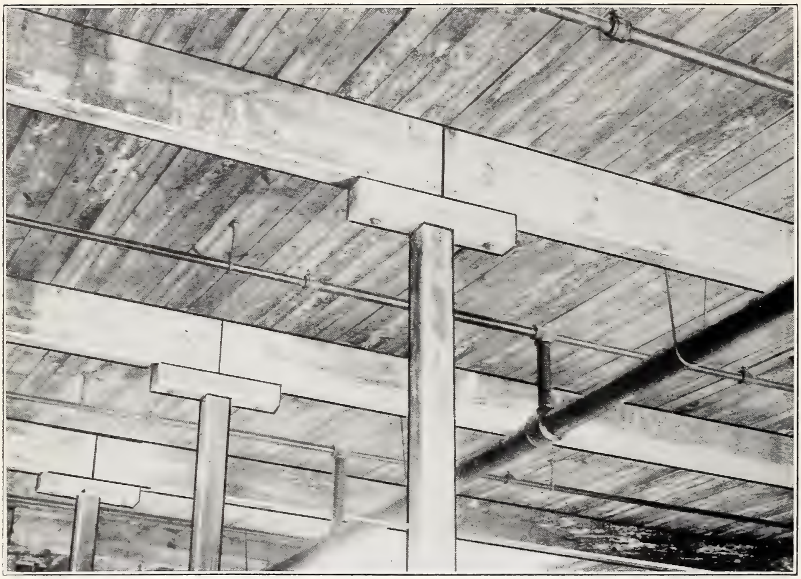


FIG. 1.—INTERIOR SHOWING SLOW-BURNING ROOF CONSTRUCTION OF A CHEAP BUT SATISFACTORY TYPE.

Note the simple method of framing post and timbers.

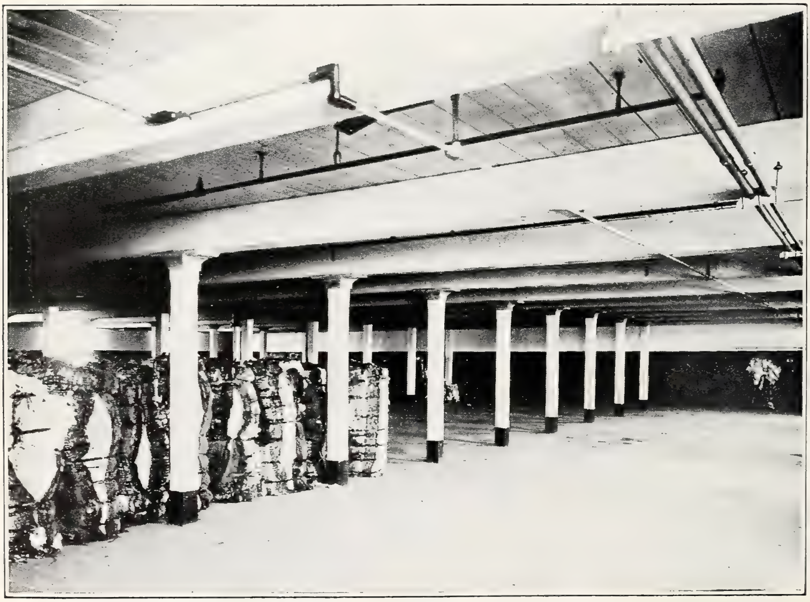


FIG. 2.—WELL-FINISHED INTERIOR OF SLOW-BURNING CONSTRUCTION.

The cast-iron post cap affords an excellent connection for timbers.

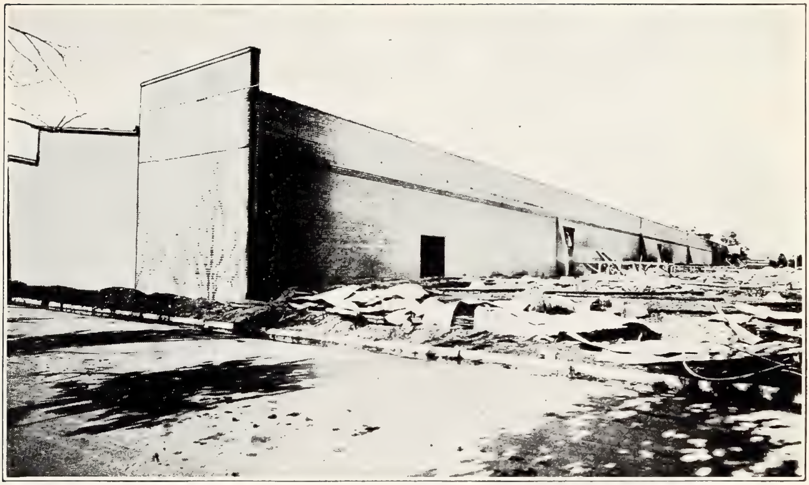


FIG. I.—A DIVISION FIRE WALL WHICH CHECKED THE SPREAD OF A FIRE THAT CONSUMED A COMPARTMENT FILLED WITH COTTON.

Note that the timbers supported by the corbel fell without damage to the wall and that the buttresses prevented buckling of the wall from heat.

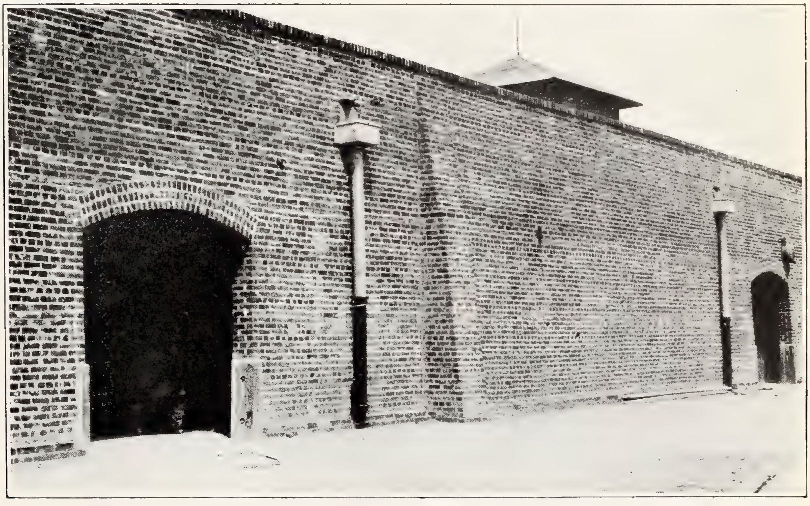
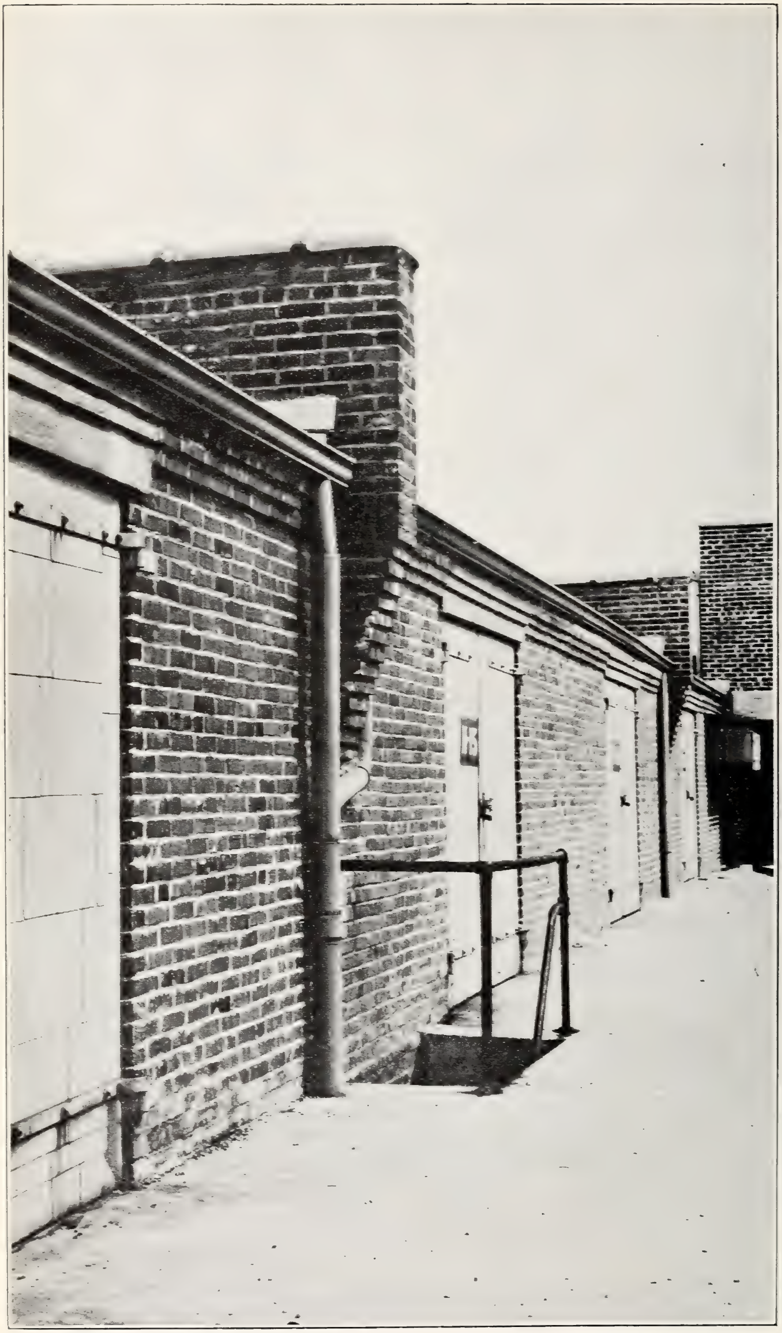
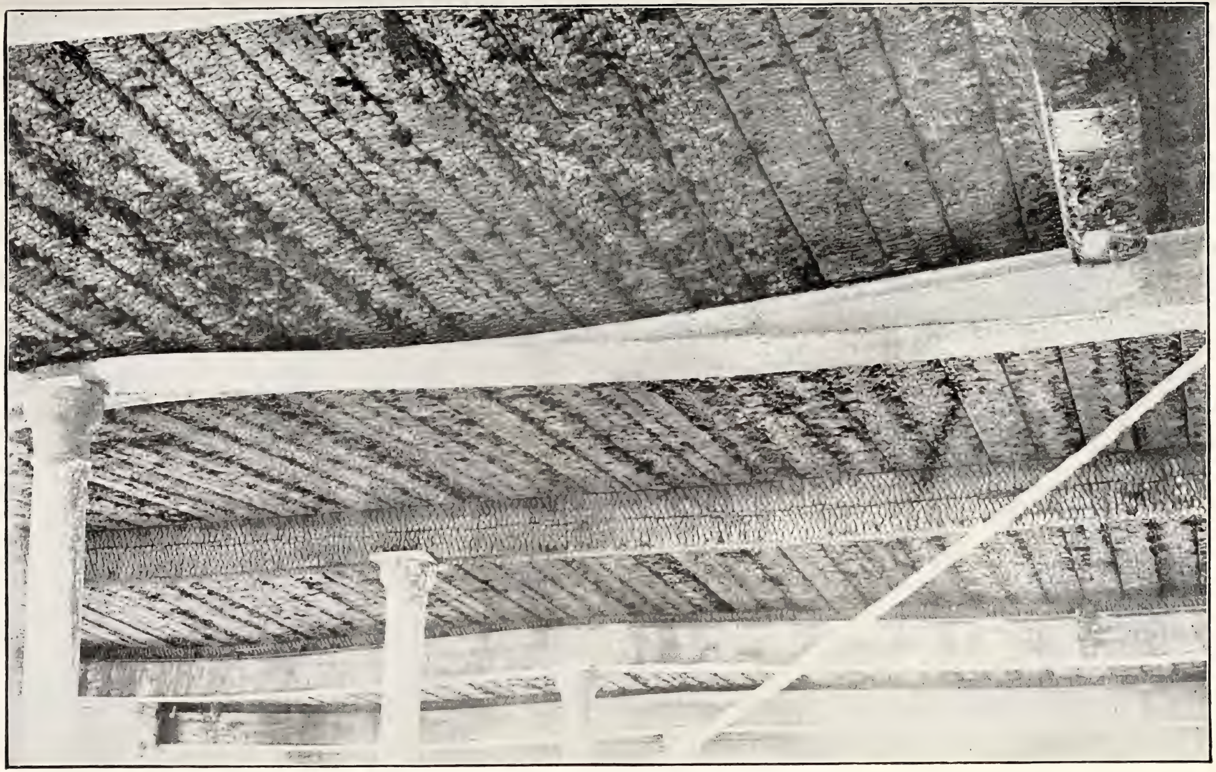


FIG. 2.—A LONG WALL BRACED BY BUTTRESSES AGAINST BUCKLING FROM FIRE.

Other notable features are the conductor head with scupper above, the lower end of the metal conductor discharging into cast-iron pipe, and the cast-iron door guards.



A GOOD METHOD OF FINISHING A WALL AND CORNICE UNLESS THE WALL IS PARAPETED.



INTERIOR VIEW OF COMBINATION STEEL AND TIMBER CONSTRUCTION AFTER FIRE.

Timbers charred but slightly damaged, while the steel beams were twisted and caused to sag by the heat and rendered worthless.

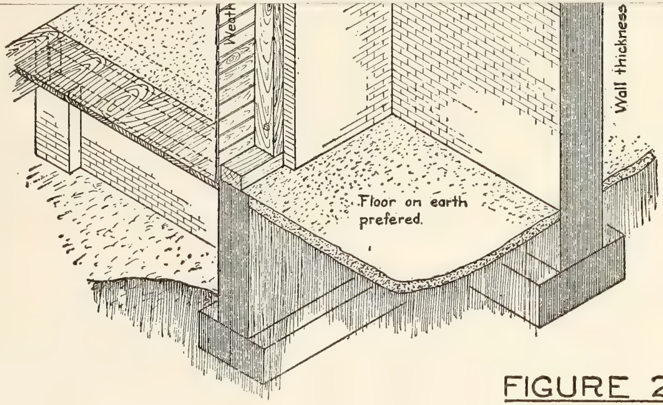


FIGURE 2.

VIEW OF FIRE WALL "T" WOOD END WALL, PAVED BREAK IN WOOD PLATFORM, AND DWARF WALLS FOR SEMI-SLOW-BURNING CONSTRUCTION.

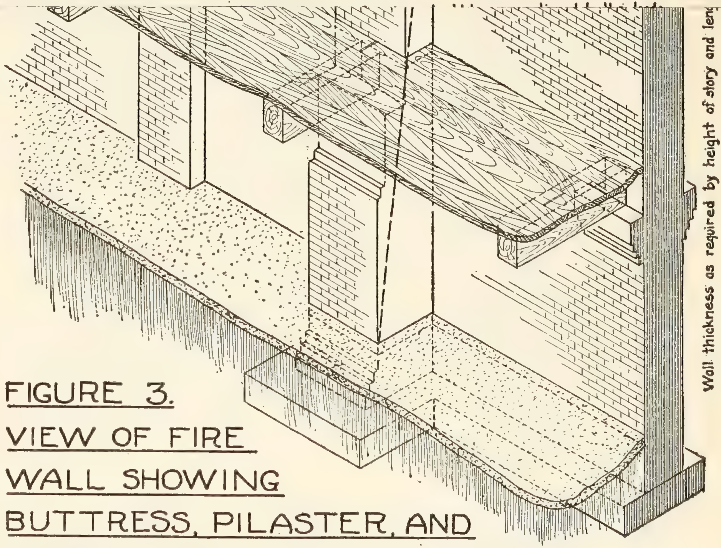
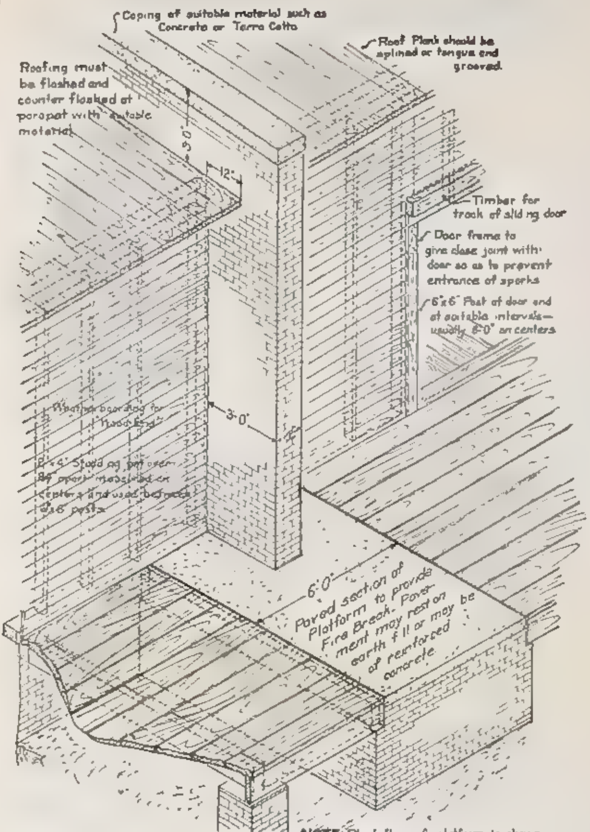


FIGURE 3.

VIEW OF FIRE WALL SHOWING BUTTRESS, PILASTER, AND CORBEL FOR TIMBER SUPPORT.

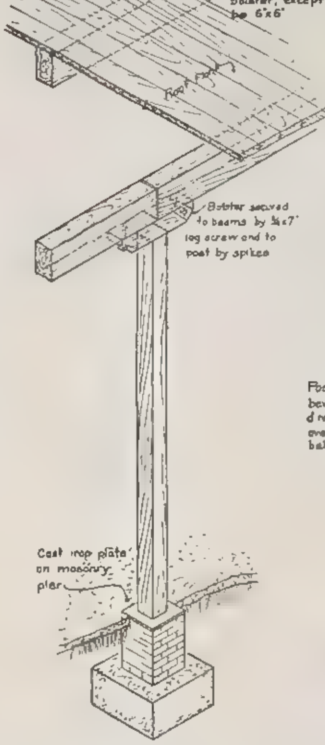
DETAILS OF FIRE BREAKS FOR SLOW-BURNING CONSTRUCTION.


Coping of suitable material such as Concrete or Terra Cotta
Roof Plank should be splined or tongue and grooved.
Roofing must be flashed and counter flashed at parapet with suitable material
3'-0"
12"
Timber for track of sliding door
Door frame to give close joint with door so as to prevent entrance of sparks
6"x6" Post at door end at suitable intervals—usually 6'-0" on centers
Weather boarding for Wood End
2"x4" Studding put over 24" apart measured on centers and used between 6x6 posts
3'-0"
6'-0"
Paved section of Platform to provide Fire Break. Pavement may rest on earth fill or may be of reinforced concrete.

NOTE: Plank floor of platform is shown only to illustrate "break". Concrete is best

FIGURE 1.
VIEW OF FIRE WALL EXTENSION WITH DWARF WALL THRU THE WOOD PLATFORM.

NOTE: Planking and framing should be proportioned to the loads required and stresses allowed for the material used, but should not in any case fall below the minimum of 2½" for Roof Plank and 3" for Floor Plank thickness; 6" breadth of beam; 8" for least dimension of post and bolster, except that wall posts used as studding may be 6"x6"


Roof Plank
Bolster secured to beams by ¾"x7" log screw and to post by spikes
Cast iron plate on masonry pier

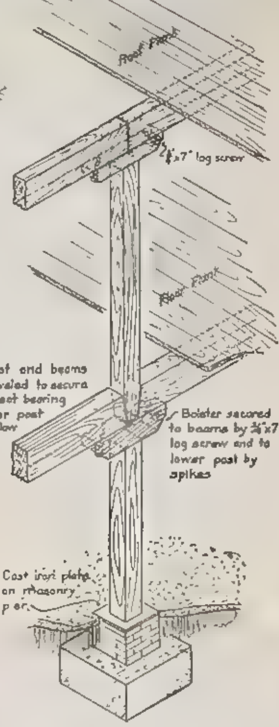

Roof Plank
2½"x7" log screw
Roof Plank
Post and beams beveled to secure direct bearing over post below
Bolster secured to beams by ¾"x7" log screw and to lower post by spikes
Cast iron plate on masonry pier

FIGURE 4.
VIEW OF POST SINGLE STORY.

FIGURE 5.
VIEW OF POSTS MULTI-STORY.

FRAMING, SLOW-BURNING.

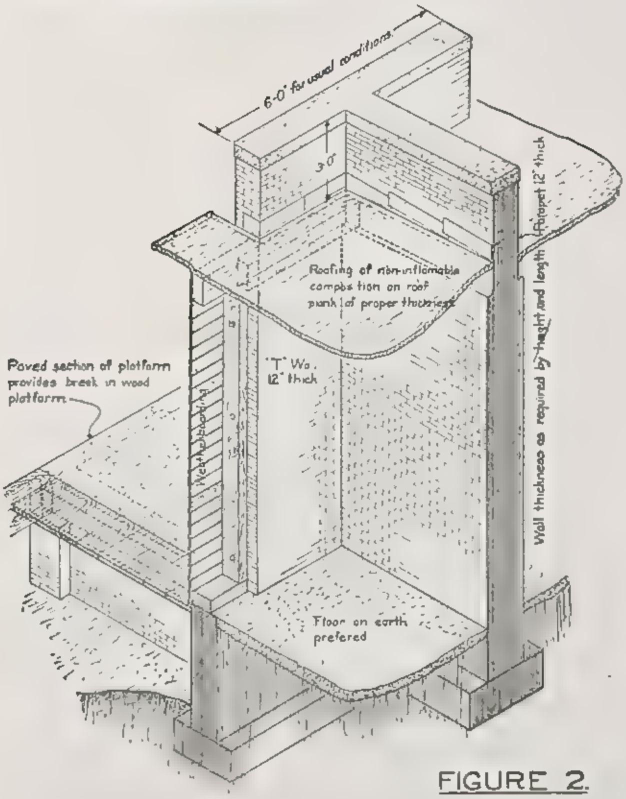

6'-0" for usual conditions
3'-0"
Parapet 12" thick
Roofing of non-inflamable composition on roof plank of proper thickness
Paved section of platform provides break in wood platform
Weatherboarding
"T" Wa. 12" thick
Wall thickness as required by height and length
Floor on earth prefered

FIGURE 2.
VIEW OF FIRE WALL "T" WOOD END WALL, PAVED BREAK IN WOOD PLATFORM, AND DWARF WALLS FOR SEMI-SLOW-BURNING CONSTRUCTION.

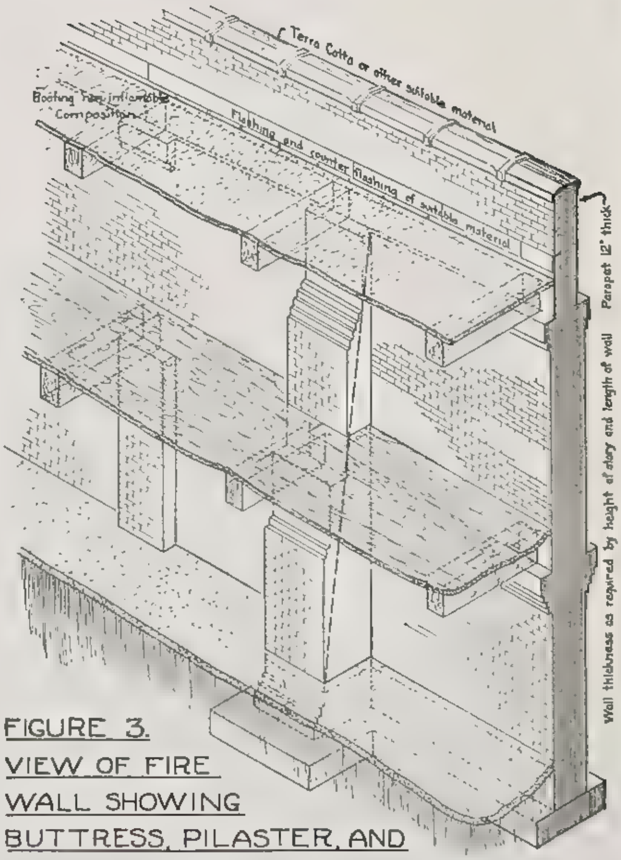

Terra Cotta or other suitable material
Roofing non-inflamable Composition
Flashing and counter flashing of suitable material
Parapet 12" thick
Wall thickness as required by height of story and length of wall

FIGURE 3.
VIEW OF FIRE WALL SHOWING BUTTRESS, PILASTER, AND CORBEL FOR TIMBER SUPPORT.

DETAILS OF FIRE BREAKS FOR SLOW-BURNING CONSTRUCTION.

Disconnected platforms affording no serious fire hazard to the warehouse are discussed under the head of "Independent platforms and sheds."

The surface of a concrete platform, for any use where subjected to constant trucking, should be of such hardness as not to wear rapidly. This is secured primarily by a top-dressing, or surfacing, of concrete mixed with a liberal quantity of cement; or by the use of sand which is not excessively coarse. Sand having grains of graduated size is preferable. Such a mortar is dense and presents a surface that wears down slowly and evenly. Further hardness may be secured by the use of special preparations which are on the market. Some of these are mixed with the mortar and others are penetrating liquids for application to the surface after the cement has set. The comparative merits of these preparations should be determined before they are purchased.

FLOOR OPENINGS.

Floor openings never should be permitted to form a direct communication between two inclosed floors or compartments. Elevators and hoist should be located on the platforms and isolated from all openings into the compartments. Where bale chutes and stairs are required, they should be placed in a similar manner.

SLOW-BURNING CONSTRUCTION.

ADVANTAGES AND DISTINCT FEATURES.

Slow-burning construction is well suited to the requirements of the cotton warehouse, although this construction does not afford such a high degree of protection as fire-resistive construction. The storage house for cotton, however, presents a combination of values of distinct contrast to many buildings in that the value of the cotton stored so very far exceeds the value of the building which protects it. Although the building of reinforced concrete will remain practically undamaged after its contents have been entirely consumed, the building of good slow-burning design will retard materially the action of fire and provide very favorable conditions for extinguishment. With acceptable designs for warehouse compartments of this construction, fire frequently can be confined to the section in which it originated. Hence the compartment is still the unit of the warehouse, as it is in case of the fire-resistive construction. The same general influences control its preferred size and proportions except that its limitations must be fixed entirely by walls, the floors not serving to separate compartment units, in case of multiple story construction.

Slow-burning construction—sometimes called "mill construction"—consists of substantial masonry walls and heavy timber framing with thick and closely laid floors and roof, all arranged so that no concealed spaces, or pockets, are formed. Although this may be considered a brief definition, there are a number of essential details which should be adhered to if the building is to be worthy of its name. For example, timbers which are carried at the end by walls should be supported there in such manner that failure and falling of the timber would not damage the wall. The value of proper construction, in this particular, is shown by the photograph in Plate XXII, figure 1, in which case heavy timbers resting on corbels have fallen without damage to the wall though an entire compartment was consumed. It is true that the first requisite is control of the fire, but a close second consideration is that damage be restricted and repair made easy.

Some general features of slow-burning construction as embodied in a well-designed warehouse are shown in Plate XXII, figure 2. The cast-iron post cap gives a good connection between the post and timbers.

DIVISION FIRE WALLS.

Division fire walls should be of the same material as that specified for such walls of the fire-resistive construction and the general requirements are the same. There is, however, one factor to be considered here that is of greater importance than it is in the case of fire-resistive construction—that is, stability against overturning or buckling from heat. In the construction having reinforced concrete floors and roof, these supply a rigid tie to the wall; but in slow-burning construction, the wall must stand upon its own merits and must sustain the shock of falling timbers and goods. Sufficient stability usually is supplied by the thickness and other proportions specified previously for brick walls of the bearing type.

An excellent fire wall is shown in Plate XXIII. The compartment was full of cotton, which was entirely consumed. Note that the heavy tapering buttresses held this unusually long wall against the buckling and overturning which a severe fire frequently causes.[1]

---

[1] The resistance to buckling of the long wall under the test of heat may be supplied by cross walls or buttresses instead of the additional thickness previously described. Buttresses should be placed at intervals not exceeding 100 feet and preferably of 50 feet. This type of buttress (shown on Pl. XXVI, fig. 3) should be built with and into the wall and not merely against it. The combination of vertical surfaces and off-sets should be such as to be equivalent to a tapering buttress (indicated by the heavy dotted line) having a projection at the first floor of one-tenth the height of the wall; the face (or thickness measured parallel to the wall) should be 24 inches. If concrete is

In order to form a complete fire break the division wall in slow-burning construction must extend well through and above the roof, this projection usually being 3 feet. If the roof has a monitor or combustible skylight within 50 feet of the wall, the parapet should extend to the level of the top of such structure. Moreover, the ends of this wall must project through the eaves or cornice of the roof in the event that such combustible material overhangs the exterior wall. This is shown by the drawing in figure 17. The portion of the wall projecting above the roof, or that extending above the bottom of the roof timbers, is known as a "parapet" or "parapet wall," whereas the extension of the ends through the cornice may be termed a "corbeled extension," or "wing wall." Openings in the division wall are quite as undesirable in this design as in fire-resistive construction and when openings are necessary they should be protected in an equally effective manner.

All parapet walls should be finished on top with a suitable material to preserve the mortar joints there. This protection is usually supplied by a coping of terra cotta or concrete. Such copings are shown by Plate XXVI; figure 2 shows a concrete coping and figure 3 a terra cotta coping.

THE EXTERIOR WALL.

The exterior wall should be of the same material and design as described for similar walls of the bearing and curtain types for fire-resistive construction. The proportions stated there are sufficient to resist the pressure of ordinary windstorms provided the wall is not excessively long and tall.

---

used, a tapering buttress as indicated by the dotted lines will be cheaper, while the design shown is suitable for brickwork.

The pilaster, such as is shown by Plate XXVI, figure 3, is of value in supporting loads carried by the wall and gives some added stability to the wall, particularly if it is tall, but the pilaster is not a satisfactory substitute for the buttress in resisting buckling from expansion.

Walls longer than 200 feet should contain expansion joints at intervals not exceeding 200 feet, and should have these free ends buttressed.

The parapet height is not figured into the height of the wall for purposes of determining thickness.

In the rare instances when a panel wall is used, the same principles should be applied to it except that the total thickness and breadth of each pilaster (or, more properly, column) should be, at the bottom, equivalent to one-eighth of this height. At least one beam should be used near the top of the wall, the beam having a depth of 12 inches or more and a breadth equal to the greatest thickness of the column but not exceeding 24 inches. This broad beam should supply the necessary resistance to buckling from expansion. The thickness of the panel would be subject to the same limitations stated for similar use in the fire-resistive construction.

Fire walls for one story buildings with a low story height of only 9 feet may be of 12 inch brickwork.

Walls longer than 100 feet and not tied by cross walls should be braced at intervals of 100 feet by buttresses similar to those in Plate XXIII, figure 2. The top of the wall should extend above the roof to form a parapet 3 feet high if there is an exposure; this arrangement is shown in the photograph just referred to. If there is no serious exposure, the wall may terminate as a parapet only 18 inches above the roof, or the wall may be finished with a corbel supporting a metal gutter as shown in Plate XXIII, figure 2. In the latter case it is important that the division fire wall provide the corbeled wing projection shown. It is preferable that there be no overhanging cornice as this is a source of fire hazard.

Walls not terminating with a parapet should have suitable wrought iron timber anchors built in and secured to the framing, in order to resist the lifting action of wind. The size and design of the anchor depends on the arrangement of framing.

Openings in the wall should conform to the same size and arrangement as stated for fire-resistive construction. Doors may be of thick and substantial wooden construction if there is no serious exposure. Windows should be metal glazed with wire-glass.[1]

FRAMING.

The usual arrangement of roof and floor timbers is such that the end of the timber is supported by the division wall. The end of any timber supported by a wall should rest freely upon a ledge, such as an offset or corbel, and not be built solidly into the wall. The free support permits the timber to fall without damage to the wall as previously illustrated. This is one of the most important details of slow-burning construction, and failure to observe this requirement leads to serious damage to the building and also rapid spread of fire. The drawing, Plate XXVI, shows such construction in figure 3 where the floor timbers are supported by corbels and offsets or by pilasters and the roof timbers are supported by corbels. These timber-ends often may rest directly upon the brickwork provided sufficient bearing area is supplied for the comparatively light load generally sustained. Timbers parallel to and supported continuously by the wall, such as frequently occur in the exterior wall, which support the ends of floor or roof plank, should be lightly anchored to the wall by bolts for the purpose, although the bearing should be directly on a ledge formed by an offset or corbel.

---

[1] A condition which requires that doors be constructed as a fire door is occasioned by the use of wood platforms. This protection should also be used in the case of doors in one story placed under those above and not separated by a reinforced con[illegible]form. Wooden doors are used only where no severe exterior exposu[illegible] anticipated. A wooden door is satisfactory if all of the provisions here[illegible]ted are fulfilled, but the fire-resistive door is much better. In any event, [illegible]s should fit close to the wall and threshold. If the exterior exposure is very severe, the wall and all openings should be constructed as in a fire wall.

Timber ends supported by posts should have a direct bearing over the post and have a supplementary connection from an iron cap or wood bolster such as is shown by figures 4 and 5 of Plate XXVI. Where a floor is supported, the post above this floor should be tapered and carried between the ends of the timbers of the floor below to a firm bearing on the column bolster or cap; the ends of the abutting timbers should be beveled so as to secure a direct bearing. Such construction is shown by Plate XXVI, figure 5. The timbers are secured by lag screws connecting them to the bolster which is in turn spiked to the post. This bolster is of further value in stiffening the timbers against deflection under load. The iron cap of suitable design may be used in place of the bolster. Use of the iron cap is to be preferred for one-story buildings where the use of power trucks is contemplated. In such cases the post should be securely framed to reduce the likelihood of its being knocked out by the truck. Posts supporting the roof should be secured to it in such manner that slight lifting of the roof by wind would not allow the post to fall. The post which is supported at the first floor should always rest on a cast-iron plate in order that there may be no penetration of moisture from the pier into the wood to cause decay, and to equalize and distribute the load over sufficient area of the pier. (The pier should, of course, be of substantial masonry such as was described for use under ground). The lower end of this post should contain a hole about 1½ inches in diameter and of equivalent depth which should fit over a lug, or knob, formed on the bearing plate. This gives stability against displacement by blows from trucking. The framing described is simple, economical, and is most satisfactory in behavior when subjected to fire. Timbers should be dressed on all exposed sides and have corners chamfered, or beveled, and splinters removed.

For preservative and fire retardant treatment of wood, see the concluding paragraphs under "Semi-slow-burning construction."

FLOORS.

Planking for floors above the ground and for the roof should be thick. All exposed sides should be dressed and edges should be well matched by being tongued and grooved or splined, preferably the latter. (In splined construction the edges of the plank provide a deep, wide groove into which a wooden strip is fitted tightly.) This construction insures a close joint, which prevents the ready passage of flame and retards the leakage of water used in extinguishing fire.

It also tends to prevent the warping which is particularly damaging to roofing. The planking should be securely nailed to timbers and all the joints should be close. Over this should be laid one layer of waterproof paper covered with a durable wearing floor about seven-eighths of an inch thick. There should be provided, however, an open joint of about one-half inch at the junction of the plank edge and wall to permit the plank to swell in damp weather; disregard of this precaution results in buckling on the floor and, occasionally, in displacement of the wall. For floors, this space should be closed by a light strip of hardwood loosely nailed at the top of the floor and carefully fitted to the wall, as this serves in case of fire to retard the passage of flame from one story to that above. Instead of this strip, or in addition to it, the masonry wall should provide a ledge, 2 inches or more wide, just under and close to the floor plank. This prevents the quick spread of fire from one floor to another.

The first floor should rest directly on the earth and should be constructed as described for fire-resistive construction. Where this entails prohibitive cost, as may be the case on a rolling site, the first floor may be constructed as described for other floors. In such case it is desirable that the timbers supporting this floor rest directly on masonry piers. These floor timbers should not be nearer than 18 inches to the ground and the space under the floor should be ventilated (through the exterior wall) if rapid decay is to be avoided.[1]

Openings seldom should be permitted in floors and when unusual conditions make such openings necessary the opening should be inclosed by fire walls with all wall openings fully protected by roomy vestibules and double fire doors automatic in operation. Such openings should be avoided by placing stairs, elevators, hoists, and bale chute well removed from all wall openings and so as to connect platforms.

ROOFING.

Roofing should conform to the same requisites set forth for material used in fire-resistive construction, although there is slightly more latitude here inasmuch as the material should be applied with nails.

---

[1] Distinction between slow-burning and the usual light joisted construction has been drawn by fixing certain minimum requirements for sectional area and dimension of planking and timbers. It is generally conceded that roof planking should not be less than 2½ inches and floor planking should not be less than 3 inches thick, with a permissible reduction in thickness of three-eighths of an inch taken off in dressing. Timbers should have a minimum sectional area of 64 square inches (equivalent to 8 inches square for columns) and should not be less than 6 inches in any dimension. (This does not refer to light wall timbers continuously supported by a ledge, these timbers usually being 4 inches by 8 inches.) In any event, the size of the timber should be such that charring to a depth of one-half inch on all exposed sides would not reduce the strength of the timber more than 20 per cent and in no case to the point of failure. All timber and planking should be dressed on all exposed surfaces. It is desirable

The variety of material and construction is usually limited to those adapted to roofs of very slight pitch since this slight incline is preeminent for warehouse designs. That the roofing material should be non-inflammable is of even greater importance for this construction than for the fire-resistive. In the case of a concrete slab the danger would be limited to access of sparks through ventilators and skylights and all fire damage would be confined to the possible loss of the roofing material. On the contrary, for slow-burning construction, the roofing material itself must serve as a protection to the roof planking against exterior fire. Furthermore, the roofing is called upon to resist the lifting, or "sucking," action of wind and, therefore, must have either considerable strength or weight or both.

There are certain elements peculiar to a fire in a cotton warehouse which render unsuitable for roofing some materials, such as tin and sheet iron, which are well suited to other purposes. It is true that these materials are proof against spark hazard from external sources, but they present a serious handicap to the extinguishment of fire which has originated in or gained access to an individual compartment. Some critics hold that the chief objection to tin or sheet iron is that when the supporting framing is burned away the metal falls upon the cotton and prevents effective application of water with a consequent heavy loss of the cotton. Others hold that it is better in case of fire that a hole be burned through the roof so as to permit the direct escape of heat and smoke in order that all openings may be used more readily for application of water. Such action is retarded when the burning framing with metal clinging to it falls bodily on the cotton. The composition roofings, on the other hand, break up under such conditions and do not present any material hazard. Certainly the feature of salvage from a cotton fire is sufficient to make the use of metal roofings inadvisable unless applied over 2-inch planking,

---

that the corners of timbers be beveled or chamfered, but in any event splinters on corners should be removed as these afford ready facility to ignition.

The wearing or surface floor should be laid diagonally or at right angles to the heavy floor plank. The surface floor may be pine, though a hardwood such as maple should be used where much trucking is contemplated.

The waterproof paper should be turned up at wall and columns 6 inches. This construction is very desirable for warehouses used by cotton mills where fire or water damage may result in a loss greater than the commercial value of the cotton because of expense and delay in making replacement with cotton of like character.

The "Regulations of the National Board of Fire Underwriters Governing Standard Mill or Slow-Burning Construction" is a concise specification of the very best practice. Every engineer and builder should endeavor to follow these recommendation which were prepared by the foremost engineers engaged in commercial, scientific, and fire-prevention work.

which would not collapse quickly. Even then, it should be adopted only with great reluctance. The roofing most fully suited to the requirements of the nearly flat roof of the cotton warehouse is tar and gravel of good material carefully applied. Its cost of upkeep is very low, while with a tin roof the cost of painting required is considerable.

The junction of roofing with parapet walls should be made watertight by extending the flashing an ample distance up the side of the wall and counter-flashing with suitable material built into the brick joint or suitable recess.[1]

ROOF OPENINGS.

Roof opening for the storage or compress compartment of slow-burning construction should conform in all particulars to the requi-

---

[1] There is now on the market a type of tile, or wall block, which provides a "raggle joint" for holding counterflashing. The eaves of the roof may extend even with the outside of the exterior wall and be finished with a hanging gutter fitted close to the top of the wall, or the exterior wall may continue above the roof to form a parapet. When this latter and better method is adopted, care should be exercised to provide ample capacity for the outlet conductors in order that excessive water may not accumulate on the roof and encroach above the flashing. As a further safeguard against such an occurrence if conductor pipes should become clogged, scuppers or openings should be provided through the parapet, the inner end of the scupper lining being soldered to the flashing and the outer end arranged to discharge water freely.

The scupper preferably should be about 5 inches high and 12 inches wide and should be so set that the top of the opening would not be above the top of roof flashing and the bottom would not be so low as to permit discharge from the scupper except in the event of stoppage of conductors.

Flashing and counter-flashing should be of durable material and usually should be metal. Copper is the best material for this purpose, but its cost at this writing makes its use prohibitive. When used it should be of the thickness known as 16-ounce, the "hot rolled" metal being suitable. Galvanized iron makes an excellent and economical flashing. Its thickness should be from 24 to 27 United States standard gauge. Care should be exercised to see that the material used does not show cracking or flaking off of the zinc coating when the metal is bent in the necessary manner. Roofing tin may be used, but is less desirable than the other materials mentioned. Such tin plates should be of the quality known as "40-pound" tin coating, and this coating may be on the lighter weights of sheet iron. Tin flashing always should be well painted on both sides. Joints in any flashing should be soldered and allowance made for expansion. The counter-flashing (which is built into the wall and turned down over the flashing) should be in long but independent sections, well lapped at joints. Guttering should be of galvanized iron, usually of No. 24 United States Standard gauge.

It is of great importance that there be no penetration of water at the junction of roof and parapet. Although the resulting damage to the cotton may be negligible, such moisture causes rapid decay of the ends of timbers, with a frequent result that such timbers which are otherwise sound must be replaced.

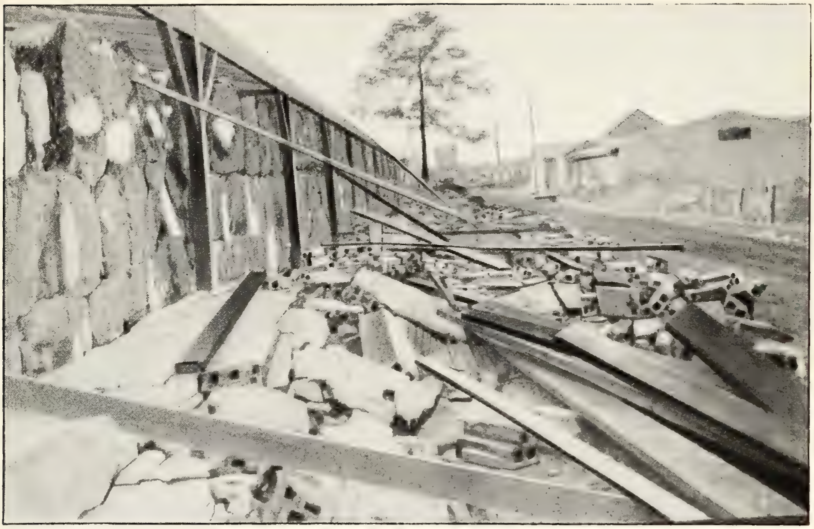


FIG. 1.—LIGHT TILE WALL DEMOLISHED BY WINDSTORM.

Note that the wall fell outward; this shows why pilasters should be placed on the outside of a wall of light material.

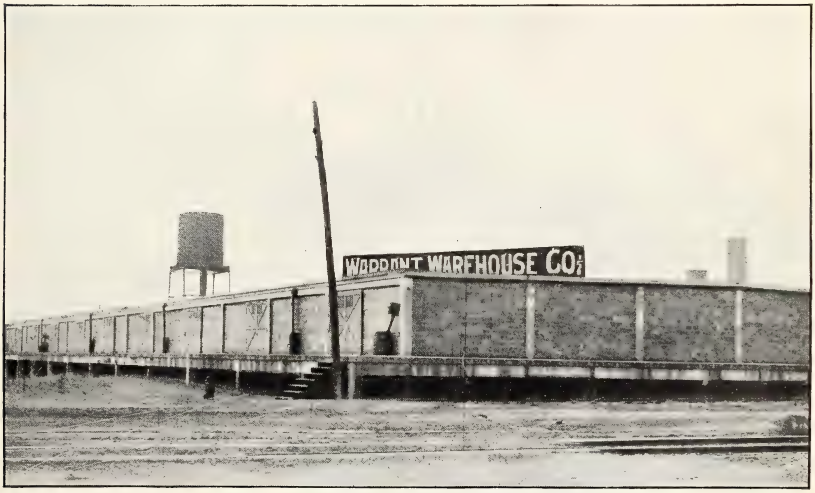


FIG. 2.—A WAREHOUSE IN WHICH HOLLOW TILE IS USED TO THE BEST ADVANTAGE.

Note that the frame, roof, and platforms of the building are of reinforced concrete.

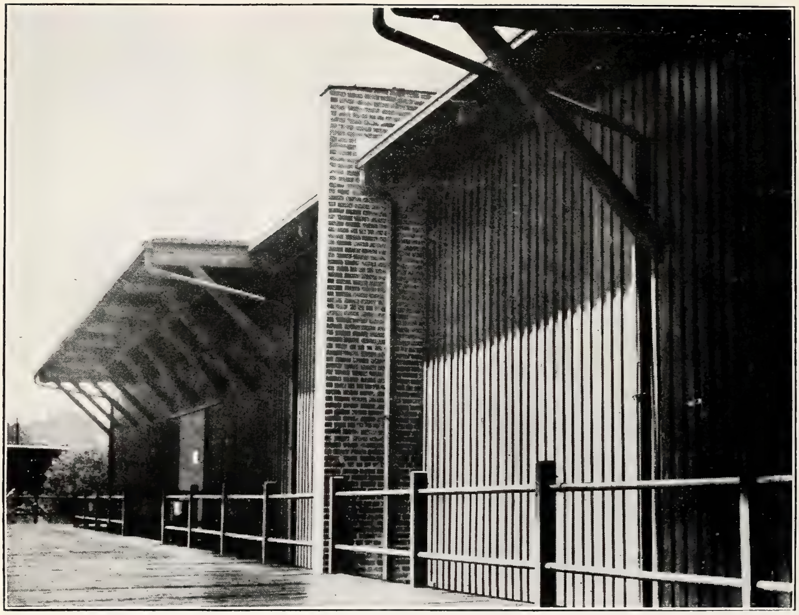


FIG. 1.—THE PLATFORMS SET OFF FROM THE BUILDING IN ORDER TO MAKE MORE EFFECTIVE THE FIRE BREAK FORMED BY THE WALL EXTENSION.

Note that the roof overhanging is drawn in on each side of the fire wall.

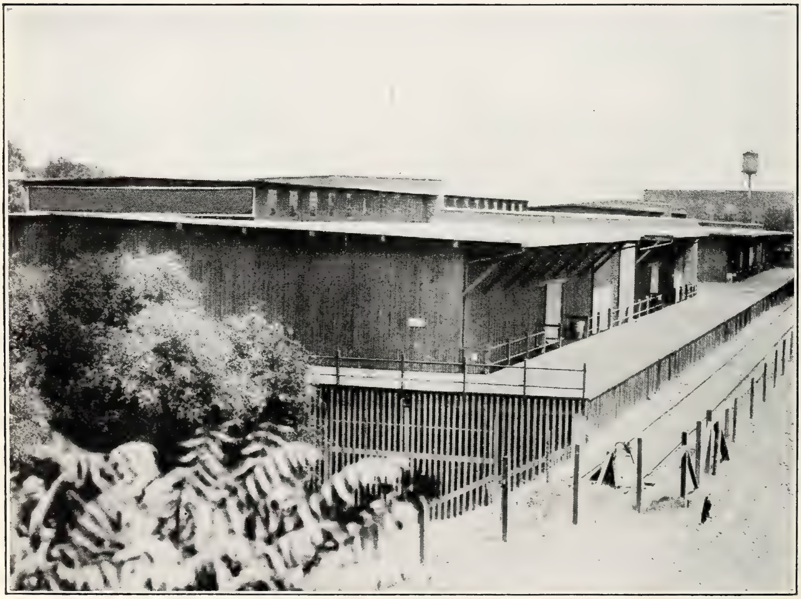


FIG. 2.—A SEMI-SLOW-BURNING WAREHOUSE BUILT AGAINST A RAILWAY FILL.

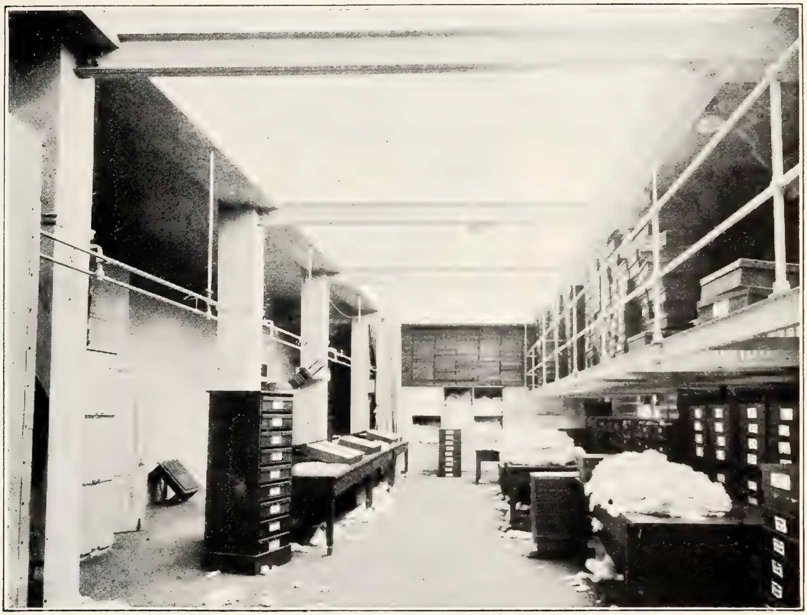


FIG. 1.—INTERIOR OF A CLASSING ROOM SHOWING EXCELLENT DISTRIBUTION OF LIGHT EFFECTED BY THE SAW-TOOTH SKYLIGHT FACING THE NORTH.

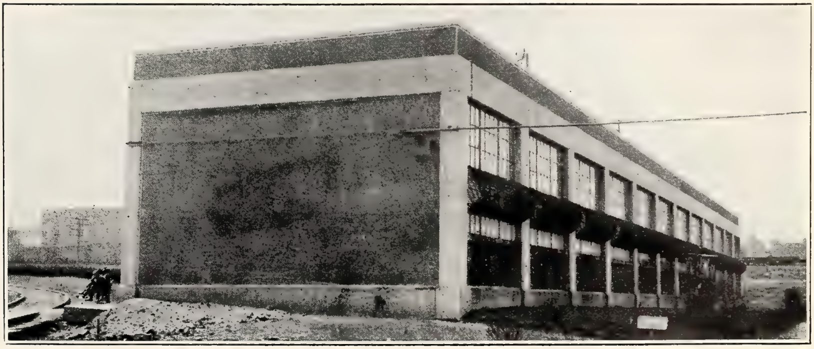


FIG. 2.—A VIEW OF AN EXCELENT CLASSING ROOM AND OFFICE.

sites set forth for such openings in the fire-resistive roof. Special care should be exercised to see that a tight joint is made at the ventilators and skylights.

PLATFORMS.

Platforms should be paved or, if elevated, built of reinforced concrete. Wooden platforms are a source of great expense for upkeep and present a good opportunity for the origination of fire. All things considered, the paved or reinforced concrete platforms are more serviceable, and, eventually, are more economical. If wooden platforms are used they should be of heavy timber, and the warehouse doors should be protected as previously described.

In view of the frequent reference to requirements of the construction for warehouses several stories in height, it is scarcely wise to conclude this portion of the discussion without pointing out the hazard such additional stories entail. The single-story warehouse of any construction affords decided advantage in dealing with a fire and is especially advantageous in the case of slow-burning construction. However, if conditions demand the storage of cotton without tiering, this single story entails a prohibitive cost of the plant per bale capacity, particularly if adaquate yard hydrant piping or sprinkler equipment is provided. In such cases there is no serious objection to providing three low stories if all stories of the compartment formed by the division fire walls contain a total of not more than 144,000 cubic feet. The resulting area (stories being of equal height) is suitable for convenient storage of 1,000 bales of uncompressed cotton or 1,500 compressed bales. Additional stories not only involve subjection of an excessive value of cotton to a single possible fire, but render the use of hose streams less effective. For slow-burning construction, not more than four stories should be countenanced under usual conditions, and these stories should be low, permitting the storage of only one tier of bales on end.[1]

Extreme caution should be exercised in the use of unprotected steel in combination with any timber construction. The weakness of steel for such use is shown in Plate XXV. In this building both steel beams and timbers were used owing to a shortage in available steel beams. A fire which damaged the timbers but slightly caused the steel beams to twist and sag as shown by the photograph. The most dangerous use of steel from a fire hazard standpoint is the use of steel rods in truss beams. There is a temptation to use this construction for increasing the span of beams and so reducing the number of columns, particularly in the compress compartment.[1]

---

[1] Additional stories may be provided by making alternate floors of fire-resistive construction, such as reinforced concrete. Even in such event, a limit of four stories is preferred and six stories should be the final limit, the third and fifth floors of reinforced concrete and all floors provided with platforms of reinforced concrete.

SEMI-SLOW-BURNING CONSTRUCTION.

A modified type of slow-burning construction for cotton warehouses is in very general and satisfactory use. This type of building is exactly like the slow-burning construction already described except that the exterior walls are of light frame and the division fire walls are modified in such manner as to form an effective fire break in these inflammable exterior walls. Also the omission of the durable top floor and waterproof paper over the heavy planking is permissible and in keeping with the cheapness of this construction. This combination may be called semislow-burning construction. It is frequently spoken of as "wood-end" construction, though this is a rather indefinite term. A general view of such a building is shown in Plate III, figure 1, and is referred to in the beginning of this discussion. The value of the semi-slow-burning construction lies in the economical restriction of cotton subject to a single fire. Provided the design of the division fire wall and the wood end is correct, this construction is very satisfactory for buildings properly separated and not seriously exposed to other fire hazard. This design is especially economical of construction in communities where lumber is readily available and masonry materials are scarce.

EXTERIOR WALLS.

The exterior walls constructed of light frame afford advantages in some cases to firemen, since the boards can be pulled off readily, thus providing openings through which hose streams may be played effectively upon the fire. The disadvantage of the wood-end wall is that it does not afford adequate protection from fires of exterior origin. Therefore these two considerations are favorable to the use of very light framing, such as 2 by 4 inch studding, carrying lapped siding, or weatherboarding, combined with heavy posts that support the timbers carrying the floor or roof plank. Thus if the fire gains sufficient headway to make destruction of the light inclosure necessary it may be accomplished easily; or, in the event of the fire having made dangerous progress, the light inclosure may be burned away and still leave the roof or floor adequately supported for a time. The siding should be applied horizontally and with edges of boards well lapped so as not to permit the entrance of sparks. Vertical boarding is less desirable unless the joints between planks are well stripped. Siding may be the ordinary resawed beveled weatherboarding, either sized or dressed. The dressed material is to be preferred unless the wall is to be whitewashed, in which event the rough material affords a better surface for the whitewash. This frame wall may be left unfinished or it may be whitewashed, stained, or painted. Whitewash affords good protection against attack of flame, but the result is unsightly unless the mixture is colored and frequent applications are made. Stains made with creosote may be used, or the wall may be painted with such paints as do not burn readily.[1]

---

[1] Usually the steel rod equivalent to 1 inch square is subject to a stress of 16,000 pounds which it readily withstands at a normal temperature, but with ordinary temperatures reached in a fire this strength is reduced quickly to so low a value as to make failure certain and prompt.

Steel or wrought-iron timber hangers or post caps are less objectionable than steel truss rods, as a partial yielding of the timber hanger does not alter as seriously the mechanical stress which remains equal to the sheer load of the beam.

If it is necessary to secure spans longer than is economical with timbers, trusses may be used provided all members (both tension and compresion) are of wood having the dimensions of no side less than 6 inches and are such that charring of all sides to a depth of one-half inch will not reduce the strength of the member more than 20 per cent. Steel or iron should be used only for bolts enclosed or insulated by the wooden members.

Clay wall tile may be used as a substitute for the frame wall of single-story buildings. The thickness of tile need be only 6 or 8 inches, provided it is suitably tied or braced against wind and guarded from the piling of cotton bales against it. These precautions are absolutely essential. Disregard of them with consequent failure from wind is shown in Plate XXVII. Here the light thin tile wall was completely demolished by wind. It should be noted that the wall fell outward—a very common result of the "sucking" action of wind on the unexposed side of a building. It is stated on good authority that the storm which destroyed this wall was not extraordinarily severe. Clay tile may be used satisfactorily, however, for thin walls, provided the wall is sufficiently braced by pilasters or other device. The wall should be built independently and outside of framing supporting the roof. This reduces the extent of possible wind damage, permits ready breaking through in case of fire and lends itself to economy and efficiency in original construction. Such a wall is economical in upkeep and affords far less spark and exterior fire hazard than the wood end. This type of wall may be termed a paneled tile curtain wall.[1]

---

[1] Framing of the exterior wall should be constructed so that sills will be raised above the ground and protected from moisture. It is desirable that the light sill, or "shoe," be raised about an inch above the platform and with the boarding overlapping, as a protection from the weather. This suggests an advantage of horizontal siding over vertical boarding, as in the first instance only one or two boards would be subject to rapid decay, whereas the ends of all vertical boards would be subject to decay from moisture. A very economical manner of framing is that used in the large export plant illustrated in Plate II. In this instance the paving that forms the floor and platforms is laid continuously and supports the light weight of the wood-end wall. The sill is 4 by 4 inch pine cut in between the main roof supports. The ends of this sill rest on the cast-iron plate carrying these roof posts, and the sill is supported at intermediate points by small cast-iron plates having a lug, or knob, projecting into an auger hole bored in the sill to prevent displacement of the support. The main roof-supporting posts, for both the wall and interior locations, rest on plates supported by small concrete or brick piers. Where such construction is used, it is important that the floor be raised about one and a half inches above the platform, the change of level being made at doorways by a slope inside the compartment and elsewhere by an abrupt drop or a slope back of the siding. Otherwise blowing rain will result in water damage to cotton near the walls. Studding for weatherboarding should be set about 24 inches apart. Where there is more than one story the wall for each story should be of separate lengths of studding. The upper wall framing should be carried by the respective floors.

Doors and windows for either the wood or tile wall should be provided in the manner described for masonry walls for slow-burning construction, except that there is never any occasion for doors to be tin covered. It is best that windows be glazed with wire glass in order to reduce breakage. There is no objection to omitting windows entirely so far as dealing with fire is concerned, as either type of wall can be broken through readily. Steel sash are economical when upkeep is considered, even when used in a frame wall, but wood sash may be used if desired.

DIVISION FIRE WALLS.

Division fire walls in their relation to the frame exterior wall are shown by Plate XXVI. The T wall construction is shown by figure 2 of this drawing. The width of the part of the T that forms a section of the exterior wall should be 6 feet. Only very exceptional conditions demand the increase of this length. If a wooden platform is used the portion of the platform adjacent to the T of the division wall should be of concrete. This may be a paved section supported by low wall and earth fill or it may be of reinforced concrete. The exterior wall shown by figure 1 forms fully as good a fire break as the T wall and is much cheaper in construction. If the platform is of wood it should be broken at the division fire wall by a paved section 6 feet or more in length as shown by the drawing. The extension wall itself should project 3 feet beyond the frame or tile exterior wall. Such extensions should not be counted in the length of the wall for determination of excessive length as effecting thickness. Neither is it necessary that the required wall thickness be used for this portion of the wall, as 12 inches is satisfactory. For either design the top of the division wall, including the extension or T section, should extend 3 feet above the roof and should be finished with a coping as described under "Slow-burning construction." As in that instance, the parapet should be 12 inches thick, this same thickness being used for the T wall or the extension for any reasonable height of wall.

---

[1] Paneled tile curtain walls should not exceed 15 feet in height. For heights less than 10 feet, 6-inch tile is suitable, while for heights of 10 feet or more 8-inch tile should be used. Pilasters should be constructed at intervals of 10 feet or less on centers and should be at least 1 foot wide. The pilasters should be coincident on each side of the wall and should have a total thickness of at least one-eighth the height of the wall. Tile blocks should be laid with joints well broken and tiles forming the pilaster should be bonded with those forming panels. The pilaster construction requires that these blocks be laid on end. Good bonding is secured by laying metal wall ties, metal lath, or even strips on 1-inch mesh poultry wire in the horizontal joints. This last method is fairly satisfactory and involves extremely little cost. Door openings should be laid up with brick reveals forming pilasters of the usual dimensions. The lintel may be constructed very economically by inserting a steel rod in a row of blocks filled with concrete. The blocks are stood on end in the number required for the lintel, the steel and concrete is inserted, and the lintel is left in this position until the concrete has set sufficiently for use.

The same factors governing preferred designs are to be found here that were pointed out in the discussion of slow-burning construction. The features of compartment size and number of stories are the same. The use of concrete platforms is even more important than in the former case. The exterior wall should be of light framing weatherboarded and should provide sliding wooden doors. Thin tile curtain walls may be used to good advantage, but do not justify a very great increase in cost over the frame. Division fire walls may terminate in either manner described. The T wall costs more but is an advantage if platforms are narrow. The projected extension wall affords fully as satisfactory protection.

The roof of the eaves should extend over the wall about 12 inches. A hanging gutter is a very desirable finish. Wind anchors for roof timbers at exterior walls of frame are of little value, but if the exterior wall is of tile, suitable anchors of wrought iron should be provided at pilasters. Posts should be secured to roof framing.

A good example of this semislow-burning construction adapted to trying conditions of the site is shown in Plate XXVIII, figure 1. Here the basement is well drained and the floor waterproofed. The fire hazard incident to the wooden platforms is minimized by the fact that the platform is really detached from the building as shown in the detailed photograph (Pl. XXVIII, fig. 2). This view also shows the fire break formed by the division fire wall.

USE AND PRESERVATION OF WOOD.

The selection of wood for the cotton warehouse is generally restricted to Southern pine, as the majority of cotton warehouses are located in the southern part of the country where that wood predominates. This natural limitation is not a disadvantage as the several species of pine meet almost every need for timber construction of the warehouse. Southern pine is among the most suitable timber also for warehouses in the Northeast and other sections of the country, but in these locations the relative economy of fire-resistive construction should insure its adoption.

Among the varieties of pine available and suitable for warehouse purposes are those commonly known as longleaf and shortleaf, there being several varieties with more or less distinct characteristics which are very roughly but commonly spoken of under these terms. The longleaf pine is superior for most structural purposes to the other varieties. Some of the chief advantageous qualities that have been accredited to longleaf pine are due to the characteristic long timbers comparatively free from defects. However, it is so nearly impossible (and certainly impracticable) to identify the different varieties of pine after they are sawed into timbers that great dissatisfaction has arisen over the specification of "longleaf pine" and this method is giving place to the "density method" of grading Southern yellow pine.[1]

Economy in the quality of timber used for the cotton warehouse generally should be affected by the use of "dense" timbers for beams and "sound" timbers for posts, all free from serious defects, and acceptance of lumber of a somewhat lower quality for the heavy floor and roof planking. The usual load is so light that the thickness required to affect slow-burning makes defects such as sound knots and cross grain less objectionable than for most purposes. Square edge plank free from wanes (bark or splintered corners) should be insisted upon.

---

[1] The basic principle of this method is that pine timbers having a large percentage of summer wood in proportion to spring wood—as shown on the end section by the dark-colored rings being close together or relatively wide or both—is much stronger than timbers of rapid growth as indicated by a small ratio for the area of dark rings. Even that variety of pine generally known as "loblolly" shows a fair degree of strength when dense timbers are selected. The U. S. Forest Service has conducted very complete tests for determining a fair method of arriving at the relative structural merits of Southern yellow pine. The report of the Forest Service was adopted by the Southern Pine Association in January, 1915, and by the American Society for Testing Materials in August, 1915. Now specifications may be based upon the density, which is indicative of the unit strength for perfect timbers, and upon the location as well as the kind and size of defects. The recommendations of the Forest Service as to density and defects and a discussion of the subject is contained in convenient form in an illustrated pamphlet issued by the Southern Pine Association. Very complete data on tests of wood is contained in Bulletin No. 556 of U. S. Department of Agriculture: Mechanical Properties of Woods Grown in the United States, 1917.

Wall siding and other planking which will be exposed to the weather or will be in contact with the earth preferably should be heart material, but, if it is to be kept well painted or is to be treated thoroughly with a preservative preparation, sap lumber may be used.

Wood for fire-door cores—the door designed to be covered with tin—should be nonresinous or nearly so; white pine or cypress is the best material.

Paving blocks of wood are excellent for the compress compartment floor. It is desirable that these blocks be set with a pitch cement and be laid over a 3-inch rough slab of concrete.

The tendency of wood to decay should be checked by either preventive methods or preservative treatment or both. Decay of wood is caused by a fungus which, under moist conditions or through lack of ventilation or infection, affects the wood with alarming rapidity. This growth not only causes rapid deterioration in timbers infected, but spreads to other timbers in the building or in the lumber yard.

From the present knowledge of the subject it appears that the occasional buyer of lumber may find his best protection in a thorough air drying of lumber as it is received. Timbers showing any indication of white mold, which indicates the presence of the fungi, should be isolated. If the presence of "dry rot" is suspected, as soon as the building is sufficiently complete it should be heated to a temperature of 115° F. and held at this temperature for at least one hour.[1]

The firedoor core, or the wooden door proper which is covered with tin, is subject to dry rot, as the absence of adequate ventilation contributes largely to growth of the fungi. The heat treatment described is essential to the life of wood so to be used. The heating should be done before the tin is applied, or preferably before the lumber is nailed together.

---

[1] After heating, the building should be thoroughly ventilated and the process preferably should be repeated for four consecutive days. If sprinkler equipment is provided it should be operative while the heating is in progress, care being exercised not to raise the temperature within 50° of the sprinkler head fusing temperature. In the usual case of warehouses not designed to be heated, the heat may be supplied by small stoves located on the ground floor with flues carried out through ventilator collars or openings. If the building is several stories in height, the plank for the upper floors should be laid loosely with 2-inch strips interposed between them and the supporting floor timbers while the heating is in process. (Of course, this requires the cooperation of the sprinkler contractor.) Thermometers should be distributed properly and carefully read, for under such conditions there will be considerable leakage of air and a wide range of difference in temperature at and far above the first floor. It is apparent that extreme care must be exercised to prevent setting fire to the building. The unfinished building and materials should be insured and a representative of the insurance interest should be present while the heating is in process.

In addition to the preventive methods and care described, preservative treatment should be used when trying conditions of humidity or poor ventilation have to be met. Discussion in some detail of such treatment is contained in various bulletins prepared by the Forest Service.[2]

Checking decay already in progress in a building is done best by removing permanently all timbers affected noticeably and then subjecting the building to the process of heating and ventilating previously described. Constant ventilation of the ends of timbers should be assured.

In addition to the strictly preservative treatment described, the application of oil paint to exposed woodwork is valuable. However, no effort should be made to paint wood already treated with creosote, as paint will not adhere to such surfaces. No paint or other surface applications should be made until lumber is dry and heavy timbers should not be painted for a year after cutting. Paint applied to partially green lumber serves to retain the moisture and is conducive to rapid decay.

Fire-retardant treatment for wood has not been developed on a commercial scale applicable to the warehouse. The only practical methods of increasing the resistance to fire offered by this wood construction is a surface application of whitewash or a water paint of similar character, or a few other paints carrying chemicals of fire-retardant properties. The most effective of these are limited to interior use. No such treatment can be relied upon to retard the spread of a hot fire.[3]

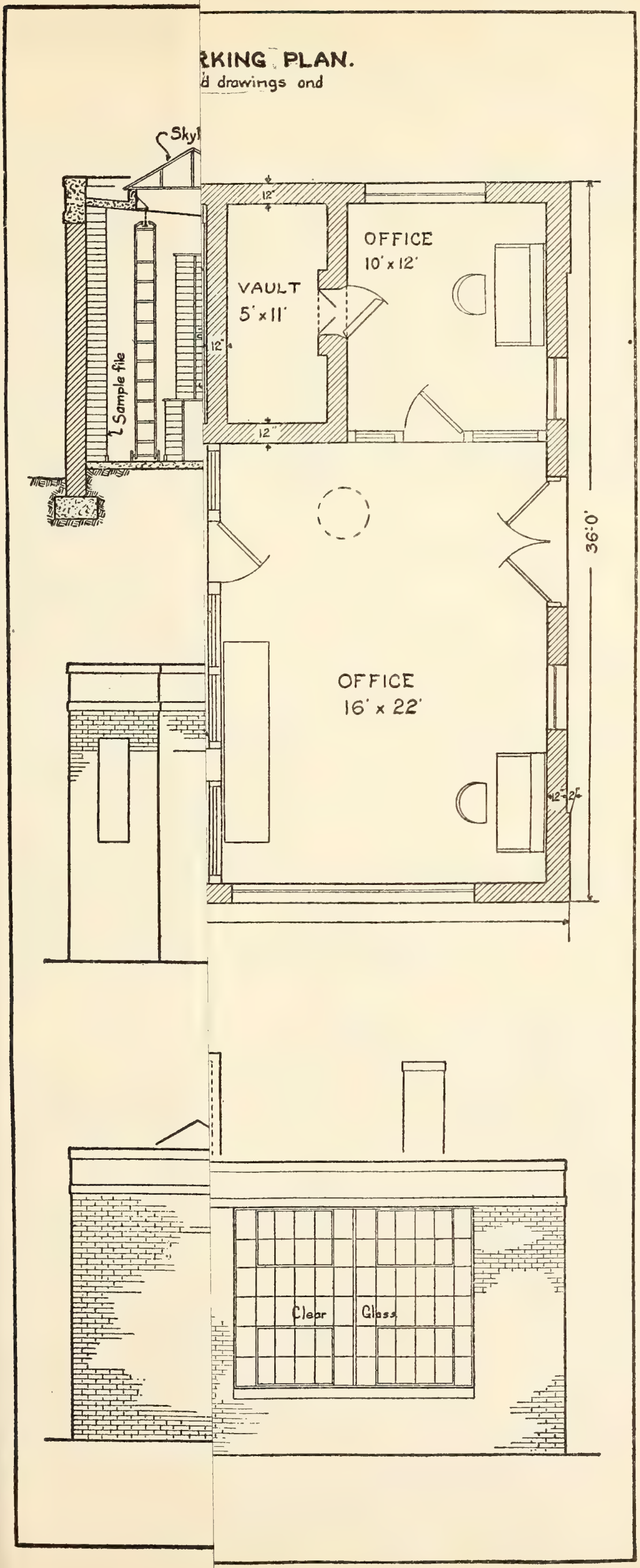
Information on the subject of yard piling and seasoning of lumber is contained in Bulletin No. 552 of the U. S. Department of Agriculture: The Seasoning of Wood, 1917.

A very fine discussion on Dry Rot in Factory Timbers is issued by the Inspection Department, Associated Factory Mutual Fire Insurance Companies, 31 Milk Street, Boston.

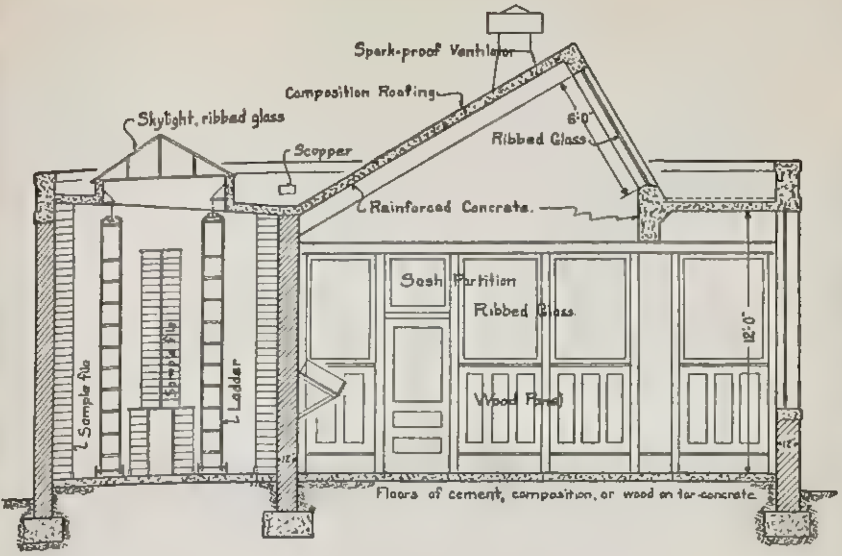
[2] See U. S. Department of Agriculture Bulletins No. 101: Relative Resistance of Various Conifers to Injection with Creosote; No. 606: Relative Resistance of Various Hardwoods to Injection with Creosote; No. 145: Tests of Wood Preservatives; No. 286: Strength Tests of Structural Timbers Treated by Commercial Wood-Preserving Processes.

[3] Below is a satisfactory formula for whitewash for interior use. For exterior use the glue and rice should be omitted and it should be remembered that no whitewash is really satisfactory when exposed to weather.

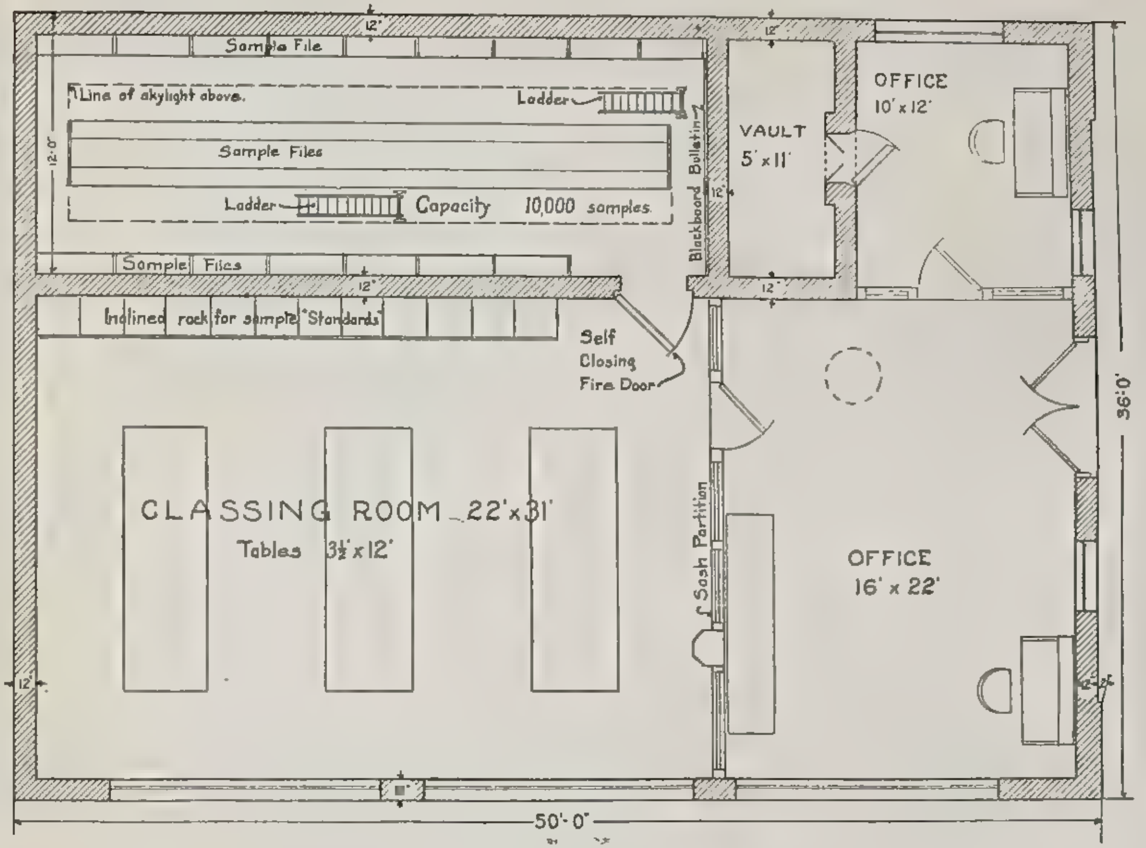
Slake one-half bushel of unslaked lime with boiling water, keeping it covered during the process; strain it and add a peck of salt dissolved in warm water; 3 pounds of ground rice, put in boiling water and boiled to a thin paste; one-half pound powdered Spanish whiting and a pound of clear glue dissolved in hot water; mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace. and when used put it on as hot as possible with painter's or whitewash brushes.


RKING PLAN.
d drawings and
Sky
Sample file
12"
VAULT
5'x11'
OFFICE
10'x12'
12"
12"
OFFICE
16'x22'
36'-0"
12"
2"
Clear Glass

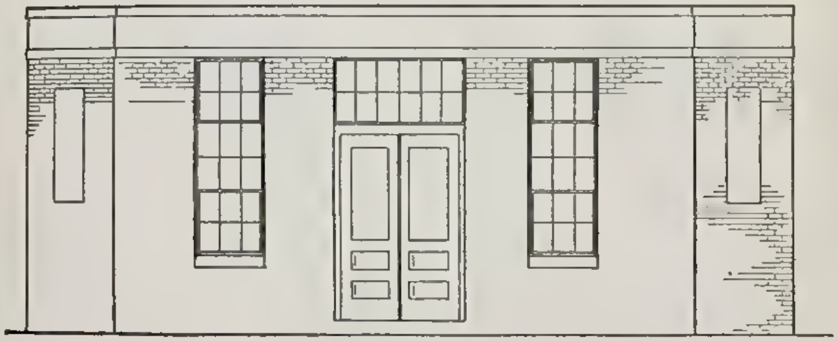
CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adapted and amplified by detailed drawings and specifications supplied by an engineer.



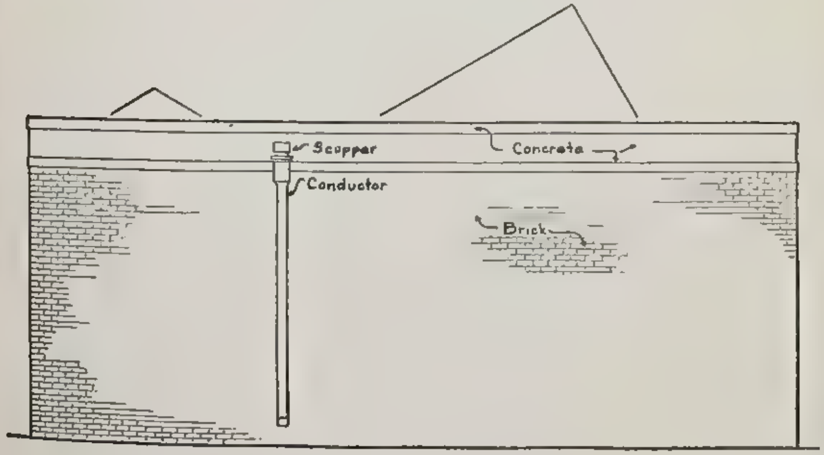
CROSS SECTION



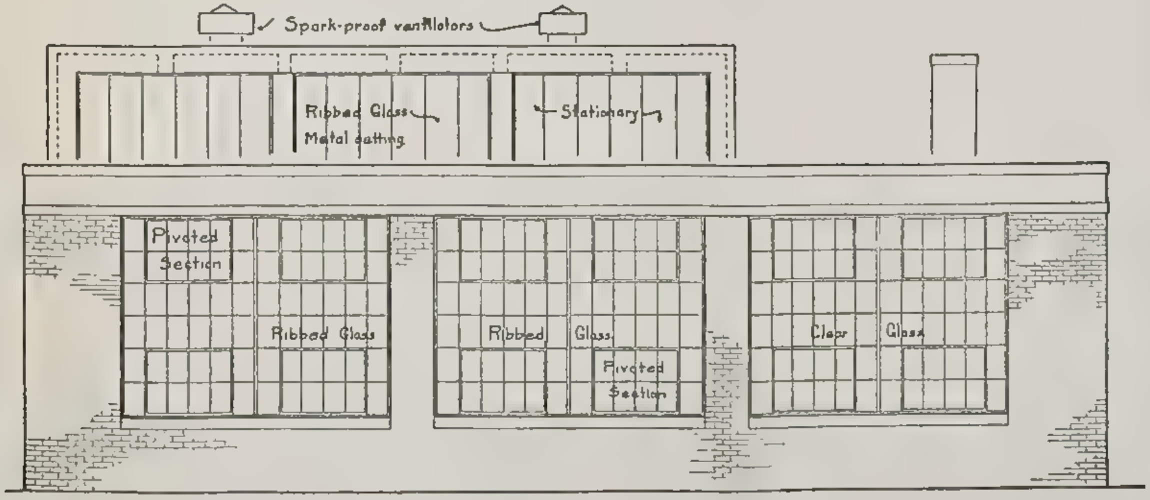
FLOOR PLAN



FRONT ELEVATION



REAR ELEVATION



NORTH ELEVATION

Plan of Combined Office, Classing Room, and Sample File Room.

FRAME CONSTRUCTION.

Frame construction for the cotton warehouse may be used in some cases. Such buildings should not be of the ordinary joisted construction, with very light rafters and thin sheeting. The roof should be of the same construction as that described for semi-slow-burning, and the walls should be the same as those used for the "wood end." It is essential that such buildings be well separated, a distance of 100 feet being required between each building and any other building. Such an arrangement generally is not economical except in case of very low value of real estate. The cost of yard hydrant piping is increased very much by this necessary scattering of buildings.

If conditions warrant the frame construction it is well to arrange the buildings in a straight line in order that possible expansion of capacity may be effected by closing in the intervening space, thus forming additional compartments in such manner as to be divided by fire walls suitably placed. Therefore it is well to adjust the area and height of the buildings in such manner as to give for them and the future additions the capacity advised for compartments. Like the semi-slow-burning design, one story is most desirable and two low stories should not be exceeded. Where two stories are used, an inclined runway, or platform, may be provided in order that cotton may be trucked to the higher level.

The construction of the roof—and floor, if there is an intermediate, or second, floor—should be of the heavy slow-burning type as this will greatly facilitate the extinguishment of fire and limit extent of damage. Moreover, such construction is but little more expensive than the light frame construction when the element of labor cost is considered.

"IRON-CLAD" CONSTRUCTION.

The type of construction commonly known as "iron-clad," or the warehouse built of a light wood frame having sides and roof covered with sheet iron, fulfills its greatest usefulness in the case of isolated small warehouses and is used largely on account of the economy with which it can be constructed. This construction is practically proof against exposure to sparks. However, the thin metal affords but little protection against heat to the framing and therefore the spacing of the buildings with reference to each other and surrounding exposures should be the same as is recommended for the frame warehouse.

The chief objection to the iron-clad building is that in case of fire the supporting framing is destroyed very quickly and the hot metal sheets fall upon the cotton and thus prevent the effective application of water. The result is that the amount of salvage from such fires is very small.

For some climates the iron-clad warehouse has a certain disadvantage from the standpoint of cotton storage because of the loss in weight caused by excessive drying-out in the great heat. This, however, is not an inevitable result as it depends upon the condition of the cotton when deposited, the local climatic conditions, and the period of the year during which the warehouse is used for cotton storage. The field for this type of building may be considered as limited to the small country warehouse.

AUXILIARY STRUCTURES.

Most warehouse plants require other structures besides the warehouse buildings. The number and character vary with the size of the plant and the nature of the business. Such structures may include detached platforms and sheds, classing room, sample file room, office, hose (or hydrant) house, pump house, and boiler house. Generally speaking, the type of construction used for these is independent of that used for the warehouse itself.

DETACHED PLATFORMS AND SHEDS.

Detached platforms, either open or covered by sheds, afford great convenience for receiving, weighing, and sampling cotton. The extent and arrangement depends on the arrangement of the plant and whether or not receipts are from wagons or cars. In any event such facilities should be ample from the standpoint of convenience to the management and the public and should allow the adequate protection of cotton from weather and fire. Consideration should be given to the type of scales used for weighing and the methods of handling employed.

Platforms may be constructed of concrete and may be either elevated and of the reinforced concrete design, or may be simply a pavement resting on the ground or on an earth fill surrounded by low retaining walls. The pavement is the less expensive usually. Such platforms afford an excellent surface for trucking, present in themselves no fire hazard, and require practically no expenditures for upkeep. If such construction is not feasible, heavy frame and planking on the order of slow-burning construction may be used. In the latter case it is desirable that supporting piers of masonry extend up to the floor timbers as this eliminates framing and bracing which contributes to accumulation of trash under the platform with the consequent fire hazard and general unsightliness. For this reason, also, the space under the platform should be inclosed by boarding.

Sheds should not be used in courts between buildings unless the warehouse is of slow-burning or fire-resistive construction. Even then the shed should not extend within 25 feet of the warehouse. Shedded courts combined with "wood-end" buildings, while protecting the cotton under the shed, tend to make the whole plant or large sections of it a single fire risk.

Sheds of the open type used over platforms or independent of them may be of fire-resistive, slow-burning, or iron-clad construction. For most situations the use of the shed does not justify the cost of fire-resistive construction. The slow-burning construction is generally most suitable for this use. Sheds covering more than 25,000 square feet should be divided by fire walls so that no area will exceed this amount. Fire doors in such a wall should not be used unless inclosed by a vestibule as described previously. Division fire walls for this use should always terminate with the T end, which should be 20 feet long.

CLASSING ROOM AND OFFICE.

A properly lighted room for grading the cotton samples is very desirable for many plants. Such a room is shown by the photograph in Plate XXIX, figures 1 and 2. The lighting here is excellent for the work as the windows and saw-tooth skylights are turned to the north so as to maintain a uniform intensity and diffusion of light as far as possible. Windows and skylights should be of ribbed glass and walls should be painted a light grey in order to minimize the glare. The tables shown afford ample space for handling of samples. Racks or tables for the boxes containing copies of the Official Cotton Standards of the United States may be placed for convenient reference.[1]

A file room for retention of samples of cotton stored is desirable and frequently is necessary. Some plants used an entire warehouse compartment for samples, but a detached building with the file room adjoining the classing room is preferable. Shelves should be so placed as to insure quick location of any sample.

---

[1] See U. S. Department of Agriculture, Bureau of Markets Service and Regulatory Announcements No. 6, 1916, and No. 41, 1919.

Office space is needed in proportion to the size and business of the plant. The office should provide ample vault space for safe-keeping of all records. The character of the vault used should be suited to the possible test it might be subjected to. Usually a vault of 12-inch brick or reinforced concrete walls and roof of reinforced concrete with approved steel doors is satisfactory. It is important that the office be in a separate building from the warehouse, since each constitutes a hazard to the other when combined.

A plan for a combined office, classing room, and sample file room is shown by Plate XXX. This plan should fill the requirements for a plant of 10,000 bales capacity. The drawing indicates reinforced concrete construction with steel sash. Fire-resistive construction is most desirable for such a building, and should always be used for protecting records and samples. Such buildings should be detached and well separated from the warehouse.

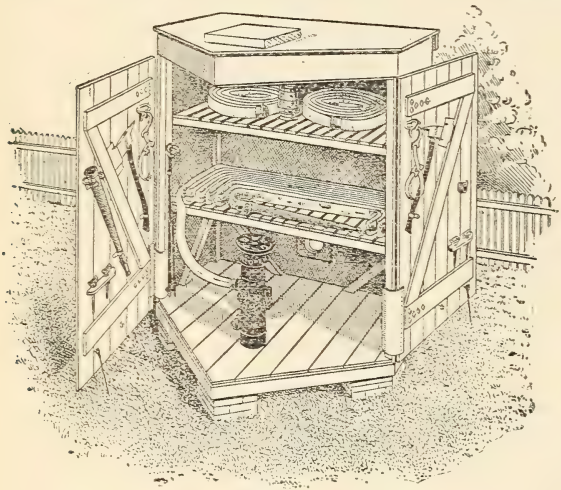


FIG. 7.—Design recommended for all hydrants, and especially for three and four way hydrants, as the attachment of the hose to the side outlets of the hydrant without any sharp bends is rendered possible.

HOSE HOUSES.

Hose, or hydrant, houses should be provided at each hydrant. The requirements for these have been so well worked out and standardized by the insurance boards that it is sufficient to state here that detailed plans and specifications for hose houses may be secured by application to the National Board of Fire Underwriters or the National Fire Protection Association. A view of one type of hose house is shown in figure 7.

PUMP HOUSE.

If the fire-protective requirements call for a pump house, it should be located in a position well removed from all exterior hazards. Even if the pumps are driven by steam from the boiler, the pump room should be either entirely removed or cut off from the boiler room by a fire wall. The construction of the pump house should be either fire-resistive or slow-burning, the former being the more desirable.

BOILER HOUSE.

If a steam boiler is needed for the operation of a press or other purpose the boiler preferably should be in a house or compartment entirely detached from the compress and storage compartment. The building should be of fire-resistive construction. Slow-burning construction for the roof, however, is satisfactory provided all exposures to other buildings are well protected by parapet walls. If a detached boiler house is not feasible, a satisfactory arrangement is to have the boiler room entirely cut off from the other portions of the building by fire walls. The dividing walls should be solid with all openings confined to the exterior wall and roof.

FIRE-PROTECTIVE EQUIPMENT.

Fire-protective equipment—frequently spoken of as "fire protection"—is of such importance for the cotton warehouse that its consideration should be given at least equal weight with the type of construction to be used. The warehouse owner will do well to consider very complete fire protection as essential and to provide the best equipment he possibly can afford. For many conditions, if capital is limited, it is advisable to determine the necessary appropriation for fire protection and then decide on the type of construction which can be undertaken. At the same time it should be borne in mind that this equipment can be added after the warehouse is built, while the building construction can not be changed readily.

The relative cost at which different features of the equipment may be provided depends in a large measure on the location and the size of the plant. Certainly no warehouse is so small or isolated that it can not be furnished with water barrels and pails, though frequently small warehouses can not provide complete fire-protective equipment. The automatic sprinkler system and yard hydrants, both connected with adequate water supplies, should be provided in all cases possible. Any warehouse having a capacity of more than 1,000 bales of cotton should have either hydrant or sprinkler equipment, and at least one of these forms of protection should be considered absolutely essential. The need for complete fire-protective equipment can scarcely be over emphasized where cotton is concerned.

Watchman service should be provided in many cases. The value of this service varies greatly with the size of plant and character of the service, while very small warehouses can not afford the expense.

WATER BARRELS AND PAILS.

Barrels filled with water and suitably placed are of tremendous value in protecting cotton. That barrels filled with water with fire pails at hand are always a familiar sight to the employees is in itself a valuable asset. The simplicity of this equipment is also advantageous, for even the most ignorant laborer can not fail to understand its use, though he might be confused by valves and extinguishers. It would seem that this subject need not be dwelt upon, but there are many warehousemen who overlook this simple supply of water or who give the matter little attention.

Water barrels should have a capacity of 60 gallons. The ordinary commercial oil barrel with one head removed serves this purpose well. The location of the barrels should be such as to insure attention as well as convenience when needed. The space between doors on the outside of the wall is very good. If the areas are large, barrels may be distributed (in pairs) throughout the compartment. This condition usually exists at a compress. Pails should be kept filled and hung over the barrels, ready for instant use. The pails should be of one of the approved fire-pail designs of heavy galvanized iron. Their capacity varies from 10 to 16 quarts, the 12 and 14 quart size being most common. The bottom should be rounded or cone shaped so that the pails will be used only for the intended purpose. They may be painted red and should have the word "Fire" stenciled on the outside.

The number and location of barrels will depend somewhat on the arrangement of the building and other fire equipment provided. For usual conditions one barrel and two pails per 1,000 square feet storage will be ample. The essentials of location are that barrels are convenient both for use and for attention. A good arrangement is shown in Plate XXXI, figures 1 and 2.

In winter the water in the barrels and buckets should be treated with sodium chloride (common salt) or calcium chloride, either of which will prevent freezing. The fouling of the water may be prevented by the addition of slaked lime (calcium hydroxide) or calcium chloride. Charcoal is also beneficial in preventing odors. Unless water is treated in winter to prevent freezing the value of water barrels may be very much reduced.[1]

---

[1] Barrels which are to be used for the sodium chloride solution (unless made with wooden hoops) should be reinforced with three-eighths inch round wrought iron hoops kept well painted, as the flat hoops soon rust out. Barrels which are to be filled with calcium chloride should be coated inside with asphaltum paint to prevent leakage.

The following tables give the quantities of calcium chloride and of sodium chloride which may be added to water and the resulting reduced freezing temperature. The specific gravity table is useful in testing at intervals for determination of the condition of the water. When barrels are refilled (as in replenishing losses from evaporation) care should be taken to insure thorough mixing of the added water; otherwise the fresh water will float on top of the

CHEMICAL EXTINGUISHERS.

Chemical extinguishers are of two general types. One contains a reservoir of water with chemicals so arranged that, when the extinguisher is inverted, the chemicals produce a reaction with resulting pressure which is capable of discharging the water with considerable force. The other type of extinguisher generates a gas which clings about the fire and does not support combustion. While both types of extinguishers are of value in some cases, neither of them should be depended upon for the cotton warehouse or compress, as water barrels and pails are more satisfactory particularly where ignorant labor is employed. There is possibly some advantage in having one 2½-gallon extinguisher at the compress tower.

YARD HYDRANT SYSTEM.

An adequate system of yard hydrants fully equipped and maintained is one of the greatest assets of a warehouse plant. Unfortunately, the value of the yard hydrant installation is often impaired because the hydrants are not located properly or because the equipment has deteriorated. Hydrants should be housed with all equipment ready for use as shown in figure 7.

---

heavier solution and the purpose of the treatment will be defeated. The data given for calcium chloride is based upon the chemically fused product generally used for refrigeration purposes. The tables are adapted from those given in Van Nostrand's Chemical Annual.

Treatment of water with sodium chloride, or common salt.

Sodium chloride per gallon solution.	Freezing point.		Specific gravity at 59° F., 15° C.	Weight of solution per gallon.	Density at 59° F., 15° C.
	Fahrenheit.	Centigrade.			
	°	°			°*B*.
0.44 pound, or 7 ounces	+25.4	−3.7	1.037	8.7	5.2
0.9 pound, or 15 ounces	+18.6	− 7.4	1.073	9.0	9.9
1.22 pounds, or 1 pound 4 ounces	+12.2	−11.0	1.1115	9.3	14.5
1.92 pounds, or 1 pound 15 ounces	+ 6.9	−13.9	1.150	9.6	19.0
2.5 pounds, or 2 pounds 8 ounces	+ 1.0	−17.2	1.191	9.9	23.3

Treatment of water with calcium chloride (fused 75 per cent $CaCl_2$).

Amount calcium chloride per gallon of solution.	Freezing point.		Specific gravity at 68° F., 20° C.	Weight of solution per gallon.	Density at 68° F., 20° C.
	Fahrenheit.	Centigrade.			
	°	°			°*B*.
1.46 pounds, or 1 pound 7 ounces	+18.0	− 7.8	1.1	9.2	13.0
1.83 pounds, or 1 pound 13 ounces	+12.5	−10.8	1.125	9.4	16.0
2.20 pounds, or 2 pounds 3 ounces	+ 6.5	−14.2	1.15	9.6	19.0
2.59 pounds, or 2 pounds 10 ounces	− 2.0	−18.9	1.175	9.8	21.3
2.99 pounds, or 3 pounds	−12.5	−24.7	1.2	10.0	24.0

Hose houses have been standardized fully by the insurance boards, from whom complete drawings and specification may be obtained. The general requirements are that each hydrant should be equipped with 100 feet of hose attached to hydrant and nozzle and an additional 100 feet coiled on the shelf; there should be one additional play pipe holder, four spanner wrenches, and one heavy mill lantern and two axes; unless the hydrant is controlled by a large hand wheel, there should be a wrench always attached and a spare wrench at hand. Hydrants should be frost proof and two or three way—that is, they should have two or three outlets. It is desirable that the outlets be equipped with gate valves. If the warehouse is located in or near a city the hose couplings should have the same thread as that used by the city fire department or else adapters—coupling with threads to fit the city connection on one end and the regular thread on the other end—should be provided. The play pipe referred to should be a smooth copper or brass tapered tube, 30 inches long, wound and painted. It should terminate with a 1⅛-inch nozzle. The hose should be 2½-inch cotton, rubber lined. Its durability is improved by running water through it several times a year. When this is done care should be taken to see that the cotton fabric is well dried before the hose is put away.

The subject of standardization of hydrant and hose threads is of great importance and lack of standardization has caused serious fire losses. Notable among such cases is that of the cotton fire of Augusta, Ga., in 1916, when fire forces with hose were sent from Waynesboro, (32 miles), from Macon (125 miles), and from Atlanta (171 miles), all to find themselves unable to use any of their hose because the threads did not fit the hydrants at Augusta. The estimated property loss was over $4,000,000. It is sometimes the case that city threads are not standard and therefore should be changed. In such instances it will be well for the new warehouse equipment to conform to the "National Standard" and be equipped with "adapters" during the time the city equipment is not standard.

The hydrants should be on mains of not less than 6-inch diameter with supply connection of equal size, or greater as the size of the plant demands. The mains should be arranged to form a loop system divided into sections so that the forced abandonment of a flowing hydrant would not dissipate the pressure or supply of water. This also allows repairs to be made with a minimum of interference to the system. Hydrants and valves should not be located nearer the building than 50 feet as the heat from fire might otherwise make their use impossible. If the court between buildings has to be less than 100 feet (a deplorable condition) or

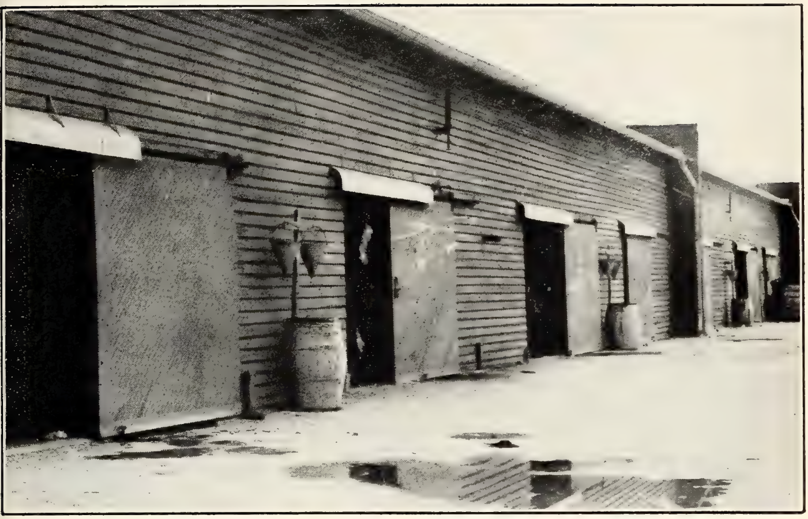


FIG. 1.—A "WOOD-END" WALL FULLY PROTECTED BY EAVES SPRINKLERS.

Note also the location of water barrels and fire pails ready for use.

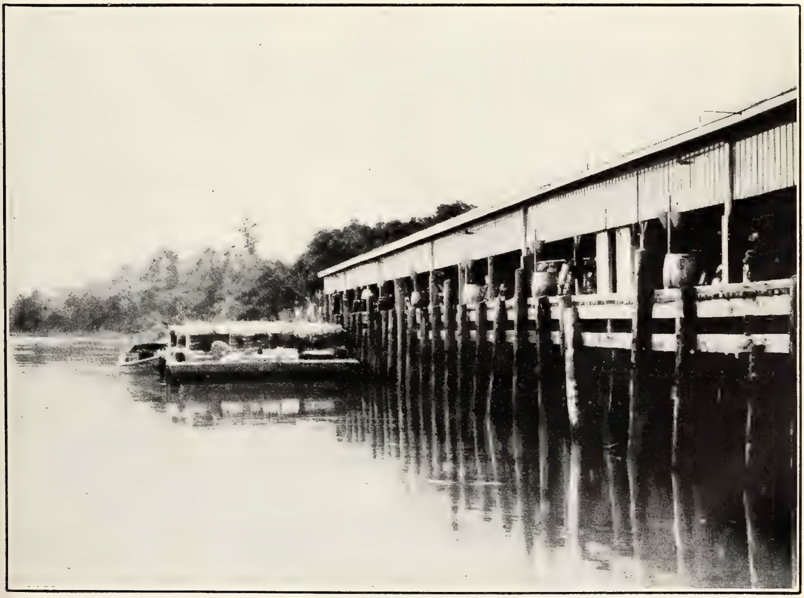
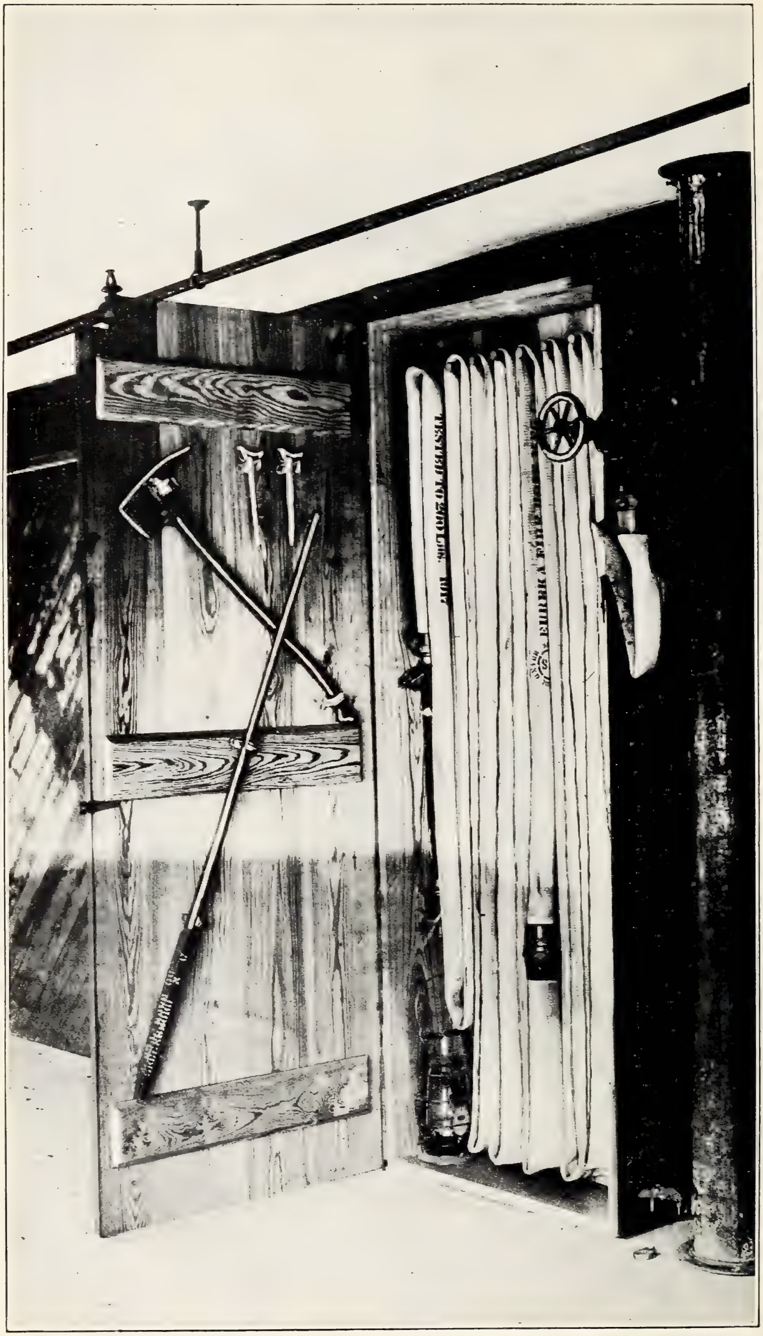


FIG. 2.—A RIVER WHARF OF INEXPENSIVE CONSTRUCTION.

The entire area is covered and fully protected by automatic sprinkler equipment.



A WELL-EQUIPPED HOSE RACK AND STANDPIPE FOR USE ON PLATFORMS OF UPPER STORIES.

if tracks conflict with the preferred hydrant location, the hydrants should be staggered, that is, alternate hydrants should be placed 50 feet or more from the building or storage area considered, the remaining hydrants being similarly located with reference to the other building. The hydrants should be spaced at intervals of from 150 to 250 feet, depending on the risk. The arrangement desirable for some conditions is shown in Plate II. It may be seen that hydrants are placed in the center of the clear space of 100 feet, except that where tracks interfere the hydrants are placed alternately on either side. The entire proposed system of hydrant protection should be approved by the insurance rating bureau and insurance concessions should be arranged before the work is begun.

The effectiveness of hydrant equipment depends largely on the volume and pressure (under flow) of the water supply. This is discussed in some detail under the head of "Water supply," but it may be stated here that the minimum requirements for pressure should be such that two streams—from any hydrant—flowing through 100 feet of hose and a 1⅛-inch nozzle will discharge 250 gallons per minute each. Good working pressure is from 60 to 80 pounds.

STANDPIPE SYSTEM.

Warehouses of more than three stories in height or having the third floor more than 30 feet above the ground should be equipped with a system of standpipes. This is a valuable adjunct to the hydrant system under such conditions. Standpipes should be located in such manner as to be accessible during fire and provide available streams for any compartment. The distance between the risers should be governed by the proportions of the compartment and the amount of hose provided. In nearly all cases standpipes should extend through platforms and provide an outlet for each platform.

Water connections may be such as to keep the pipes filled with water or the connection may be such that water is admitted only when needed. The first, or wet system, should be used whenever possible, as it provides an instant supply of water. If the pipes must be kept emptied in winter it is desirable to provide mechanical control on each floor for operating a control valve protected from freezing. If this can not be accomplished there is likely to be delay in geting water to the hose in case of fire. Dry-pipe risers should be galvanized.[1]

---

[1] If the wet-pipe system (with pipes filled with water to the hose valve is used, the hose valve should contain a drip outlet and be turned in such posi-

AUTOMATIC SPRINKLER SYSTEM.

The automatic sprinkler system is particularly well adapted to the cotton warehouse. There are few conditions which justify a warehouse of any reasonable size being without the sprinkler protection. Aside from the actual reduction in fire damage throughout the country by its use, the warehouse owner nearly always will find the automatic sprinkler a good investment from the standpoint of reduced cost of insurance. A recent survey of warehouse facilities, made by the Department of Agriculture, showed that out of 1,768 cotton warehouses reporting the 133 which were sprinklered had an average insurance rate of 36 cents while those not sprinklered had an average rate of $2.43 per annum per $100 valuation on contents. Moreover, the record of fires held in check or extinguished by the sprinkler system is most satisfactory. These facts give some idea both of the value of protection and saving in cost of insurance which the warehouseman may secure by sprinkler installation.

Automatic sprinkler installations are shown in Plates XVI, XXII, XXXI. The views show the sprinkler heads, or nozzles, placed so that a spray of water will be thrown over the ceiling and the cotton when a fixed temperature is reached, usually 165°. As shown, the piping is arranged and proportioned to give promptly an adequate amount of water flowing from a number of heads, provided the supply is satisfactory. These are the results which all requirements for sprinkler equipment are aimed to secure.

---

tion that water leaking past the valve will not rot the hose at the connection. This is a potent source of deterioration. Also, if the pressure is likely to become very high, as from direct pumping, the riser outlet should be equipped with a relief valve which would discharge and so dissipate the water pressure in case it exceeded the safe pressure for the hose. Usually one such valve for each riser is sufficient.

Each standpipe outlet should be provided with a complete hose station, each equipped in about the same manner as the hose house previously described. An exception to this equipment is that the hose may be linen, unlined, and for most cases the two lengths of hose need be only 50 feet each. The exact amount of hose depends, of course, on the arrangement of the system and building. The size of hose usually should be the same as that for the hydrants, though frequently 1½-inch hose is satisfactory. The size of the riser, however, need not exceed 4 inches and frequently may be less, depending on the number of stories. The water supply usually should be from the hydrant system. One outlet for each floor from each riser is satisfactory for most cases. A simple hose station is shown in Plate XXXII.

Standpipe systems, like the hydrant systems, have been standardized completely. The arrangement and specifications should be decided after consultation with the insurance inspection department having supervision. In this way the warehousemen may secure such recognition of equipment as the system entitles him to.

Automatic sprinkler systems for most conditions are one of the two general types, known as the "wet" or the "dry" system. In the wet system the pipes are filled constantly with water, while in the dry system the pipes are filled with air under pressure. In this latter case the fusing of a head from fire allows the air to escape and thereby unbalances the water pressure which in turn actuates a valve which admits water to the system. This valve is known as the "dry-valve." The wet system should be used wherever there is no danger of the water in the pipes freezing in winter. Where the climate affords this danger of freezing, the dry-pipe system should be used. Some of the advantages of the wet system are that water is discharged instantly upon the fusing of a head, the possible failure of a dry-valve to open is avoided, and the cost of installation is less.

Sprinkler systems may be arranged so that the pipes are filled with water in summer and yet operated as a dry-pipe system in winter. This may be accomplished by a supply pipe or "by-pass," extending around the dry-valve so that when the "by-pass" is open, water does not flow through the dry valve. Such an arrangement is very desirable.

One of the first questions to be decided is whether the system shall be wet or dry. If in doubt, the best procedure is to get bids on both systems and also a definite expression from the insurance rating bureau having supervision, as well as to make a careful study of local temperature records for a number of winters. In some instances the "eaves sprinklers" may be connected to the main system through a gate valve and drip so that the exposed piping can be drained during cold nights. However, no chances should be taken toward having a frozen-up sprinkler system. These statements refer, of course, to unheated buildings.

Sprinkler heads, or nozzles, should be so placed that all ceiling area and goods may be reached by the spray. The protection should be extended to include all platforms on which cotton is handled. The heads should be arranged to give the best protection in consideration of the construction of the building. The various drawings previously shown indicate a suitable arrangement in several buildings. Usually there should be one line of sprinkler heads down the center of each bay (space between timbers) for bays not exceeding 12 feet in width. The spacing of the head should not exceed 12 feet in either direction and preferably should not exceed 10 feet. Sprinkler heads nearest walls should not be farther from the wall than half the spacing between heads. With these provisions met, there may be allowed one sprinkler head to not exceeding 100 square feet of floor area. However, a greater number of heads is very desirable, one head for every 80 square feet being preferred.[1]

The dry-pipe system demands the use of an air compressor for maintaining air pressure in the pipes. A hand compressor is not at all burdensome for warehouses not exceeding 10,000 bales capacity. If the pipe joints are tight the leakage of air should be so slight that the system will need to be pumped up only once a week. The pressure valve, however, should be read every day.

All valves supplying the sprinkler system should be kept open and sealed or tagged conspicuously and inspected frequently in order to insure prompt action of the sprinklers. It is well for the management to keep a record of systematic inspections. Several members of the force and all foremen should be familiar with these valves.

---

[1] The position of the head with reference to the ceiling and goods is of the utmost importance. Usually the distance of the head below the ceiling should be from 3 to 10 inches, 6 or 7 inches being preferred. In the case of fire-restrictive construction, protection of the ceiling is of less importance, and the drop of the head may be increased. These requirements are appreciated when the roof contains monitors or saw-tooth skylights. In any case the sprinkler head preferably should be as much as 3 feet above the surface of cotton bales, while this distance should not be less than 18 inches, even if sprinkler heads are only 8 feet apart. Care should be taken to see that heads are not placed so close to the side of beams that the spray is obstructed.

The arrangement of piping and the size is of vital importance to effective sprinkler operation. If pipes are too small in proportion to their length and to the number of heads supplied, the efficiency of the equipment is vitally impaired in case of a number of heads opening, as this results in a marked reduction in pressure and volume of water delivered.

This suggests the importance of a suitable location for the sprinkler "riser" which supplies water to the system. A comparison of the plans previously illustrated will show that for compartments 50 by 100 feet the riser is placed in a corner; for compartments which are 100 feet square the riser should be at the center of one side, while for compartments less than 100 feet in one dimension and greater than 100 feet in the other, the riser should be located at the center of the long wall; and if the compartment is greater than 100 feet in both dimensions, the riser should be at the center of the area, as shown by the photograph in Plate XXII, figure 2. It is desirable that the riser always be placed at the center of the area, but there are frequently practical difficulties involved. For example, in a story of 8½ feet the clear height below beams is usually only 7 feet or less; obviously the lateral supply pipe extending from the riser and at right angles to the beams (between which the branch lines carrying sprinkler heads are located) would have to be so low as to seriously obstruct truckers—hence the advantage of having this supply line next to a wall. On the other hand, there are instances where alternate beams are carried by a line of girders, in which case it may be best to place the supply line under the girders in order that the branch lines may be kept well up between the beams. In the case of reinforced concrete girders of very great depth it is sometimes desirable to provide pipe thimbles (holes) in the girders

The effectiveness of the sprinkler system depends largely upon the immediate availability of water under adequate pressure. A sprinkler supplied with water at 10 pounds pressure will discharge about 20 gallons of water per minute, while with the pressure at 60 pounds the head will discharge nearly 50 gallons per minute and distribute the water better. The pressure adopted should be governed by the resulting pressure under flow considered with the cost under the given conditions. For example, gravity tanks, generally used as a primary supply, should have such elevation that the bottom of the tank will be at least 30 feet above the highest sprinkler head. This subject is discussed further under the head of "water supply."

The automatic alarm service which the sprinkler system affords is a most valuable feature. These alarm gongs may be controlled

---

in order that the supply line may be run through them, but this arrangement should be avoided if possible.

All pipe lines should be supported securely and in such manner as to secure a permanent grade for drainage of the system. Sprinkler heads always should be turned up.

In the arrangement of piping and heads for reinforced concrete buildings of several stories there will be found frequently a great advantage in the use of a "flat-slab" system of construction in that fewer sprinkler heads may be required or a reduction in story height may be permissible. In any type of construction a slight increase in cost of the building, due to spacing or arrangement of beams, etc., may be more than justified by a saving in cost of sprinkler equipment. Therefore, it is well to plan always for the possible use of sprinkler equipment even though it can not be installed immediately.

It is of primary importance that there be a proper arrangement of supply lines and control valves. It is essential that the control valve be so located as to be accessible during fire for conditions may arise making it desirable to cut off the supply of a section, as, for example, if the roof of one compartment collapsed; otherwise the water supply and pressure may be dissipated to such an extent as to impair the operation of the whole system. Therefore, it is desirable that each compartment system be controlled by a post indicator gate valve (a valve which registers whether open or closed) located if possible 40 feet or more from the building. There should be no valve inside the compartment as they may be closed inadvertently. In the case of a dry pipe system one dry valve may be used for the equivalent to five single-story compartments each 50 feet by 100 feet. In such case it is desirable that the dry valve be located 50 feet from the building, with the supply from the dry valve controlled by a post indicator valve. On the discharge side of the dry valve, and beyond the dry-valve by-pass, mains should be taken off to each compartment, each main controlled by a separate gate valve, preferably of the outside screw and yoke type. These valves, with the exception of the post indicator supply valve, should be located, preferably, in the pit with the dry valve. Some plants provide the dry valve near or inside of a compartment, thus affecting a considerable saving in piping. Such an arrangement is satisfactory, but is not so good as that previously described.

When the dry valve is used, it should be placed in a frost-proof pit underground or in an insulated frost-proof room. It is an easy matter to prevent freezing of the valve at locations in the cotton belt, but farther north a small amount of heat must be provided.

by a water motor which operates the alarm when there is movement of water flowing through the pipes; or the alarm may be operated by electricity, the operation being caused by a flow of water. The water motor alarm is generally used for the cotton warehouse. There should be a separate alarm for each branch main, which usually means a separate alarm for each compartment. (See the discussion of signaling systems.)[1]

The warehouseman who is considering sprinkler equipment would do well to employ an engineer to handle the contract and negotiate with the insurance companies. The warehouseman, however, may be able to get information as to the cost of such equipment by applying to the sprinkler company's engineers, but he should secure insurance concessions before letting the contract in order that he may know what saving and increased revenue will be affected. Some plants can pay for sprinkler equipment by resulting insurance savings of a few years.

WATER SUPPLY.

The water supply available or which may be secured at a reasonable cost frequently limits the fire protection of small warehouses. Under most conditions a warehouse should not be constructed unless a reasonable supply of water can be provided.

Water supplies are considered as "primary" and "secondary:" the first being the source from which water is furnished automatically to the sprinkler or hydrant systems, while the secondary supply is the means for supplementing the first. The secondary supply may be controlled automatically or by hand.

The usual supply of water for the warehouse is the city main connection and a gravity tank, the tank, used as a primary supply, being filled from the city mains. The tank gives a constant head of water in case the city supply is interrupted, so it is of greatest importance that the tank be kept full. For the warehouse plant of ordinary size such a supply is all that should be required provided the city supply itself is satisfactory. Fairly good protection is afforded by the city connection alone, the objection to this being that water may be cut off at times for work on mains.

---

[1] The detailed requirements of the sprinkler system have been so completely worked out by the National Board of Fire Underwriters that it is undesirable to have duplication of these specifications here. Moreover the sprinkler system involves the use of various valves and other equipment which must be tested by engineers such as the service supplied by the Underwriters's Laboratories.

For warehouse plants maintaining a central watch station, or for other extensive plants, the automatic supervision service should prove of value. This consists of a system of electric signals which will give an alarm and register at the watch office any interference with valves, water supply, pressure, flow of water or low air pressure of the dry system.

If the warehouse plant is very large and a satisfactory city supply is not available, the gravity tank should be used as the primary supply and suitable pumps with abundant water available should constitute the secondary supply. These supplementary pumps are always desirable for a very large plant. With the combination of tank and pumps the system is complete in itself, as the pumps may be used for filling the tanks, though these may be filled from the city supply.[1]

The water pressure maintained for hydrant protection should be from 50 to 80 pounds, the minimum being that which will give two standard hose streams as previously described. The actual delivery of water is made the minimum test because the actual pressure under flow may be very much less than that normally registered by the pressure gauge, because of the length, small size, or bad condition of the yard piping. The pressure used for the sprinkler system may be that used for the hydrant system, the same supply lines being used for both. If a low gravity tank constitutes the sprinkler supply, the bottom of this tank should be at least 30 feet above the highest sprinkler heads. In many instances the gravity tank is from 75 to 100 feet high. Frequently an elevation of the ground can be used to advantage in affecting a saving in height of the tank tower.

The yard piping system should always be arranged as a "loop system" so that water from any source can be delivered to any point without undue friction loss. The system should be divided into sections by post indicator gate valves in order that changes or repairs may be made in any part of the line without putting the entire system out of use. Repairs and changes, when necessary, should be made with as little interruption to the service as possible. The loop and section arrangement is of great value in case of a severe fire when open hydrants may have to be abandoned as such an arrangement is of value in conserving the water supply and pressure. sure.

---

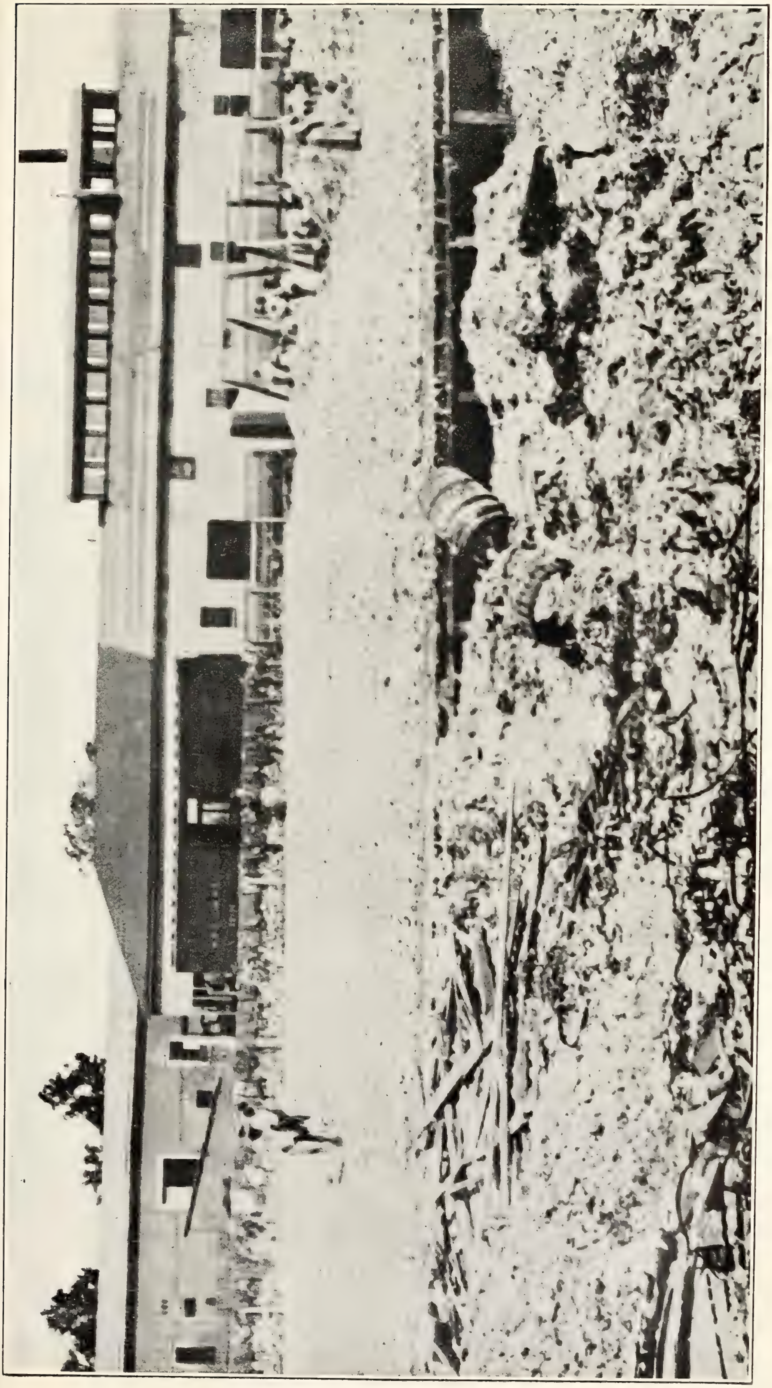
[1] Each source of water supply should be protected against every other supply by check valves. The need for this is apparent from the following illustrations: Suppose a gravity tank primary supply is connected with a city main and the city connection is not protected by a check valve, the drainage of this part of the city main would drain the tank also and leave no water supply. Again, if the tank and pump supplies are used the tank is at an elevation designed to give the pressure desired for the sprinkler system with dependence placed on the pumps for hydrant pressure, the desired increased pressure and supply from the pumps when in operation will be dissipated by overflowing of the tank unless it is protected by a check valve. Or if the tank is not protected against greater city pressure the same overflowing and loss of pressure would result. Check valves to protect tanks should always have a by-pass around them in order that water may be forced through the by-pass into the tank. The by-pass valve should be of the post-indicator gate type.

Fire pumps include three preferred types—the duplex Underwriter's steam pump, the centrifugal pump (usually electrically driven), and the rotary pump (usually mechanically driven). The available power often determines the type of pump used. If it is practicable to keep up constant steam pressure, the steam pump should be used, while if steam is not available throughout the season the steam pump should be supplemented by an electrically-driven centrifugal pump, usually of the double-stage type. The rotary pump meets such conditions as are furnished by water power as the available drive. Generally speaking, the steam power is the most reliable. If electric power is relied on entirely there should be two supplies of current if possible. Pumps should deliver water at 100 pounds pressure. All pumps should be kept in the best condition and run for a few minutes every week. Main valves should be kept open and suction lines and intake strainer kept clean.

Gravity tanks are usually of steel, as it makes a durable tank which is economical for most conditions. If a natural elevation of the ground can be used so as to reduce the height of the tower, tanks of reinforced concrete are excellent, the economy of this type of tank depending largely upon the local cost of the materials and whether or not other concrete work is being done at the time. The capacity of the tank should not be stinted as a large supply is very desirable. Moreover, the cost of the tank should be less in proportion as the capacity increases. Again, the extra capacity may permit a future extension of the plant without the necessity of an additional tank. Wooden tanks are sometimes used but their liability to decay makes their use inadvisable for most conditions. Gauges for registering the amount of water in the tank always should be supplied.

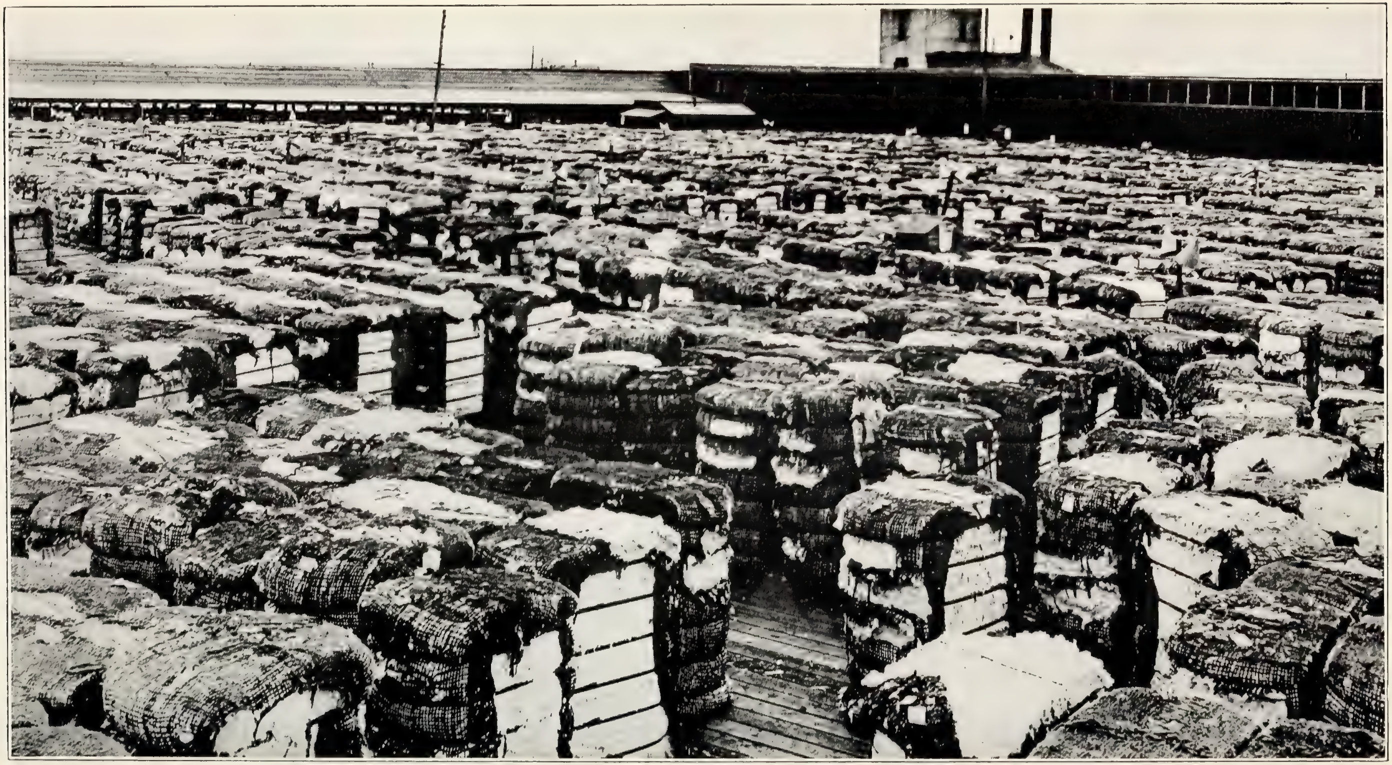
Freezing of water in tanks and risers during winter must be guarded against. For the greater part of the cotton belt the only precaution necessary is that the tank riser pipe be insulated. A wooden boxing packed with dry sawdust and made water-tight frequently will be found sufficient. Colder climates demand that the water be kept heated slightly during cold weather. This is accomplished by means of a special tank heater arranged and connected so that there is a constant circulation and even heating of this water in both tank and riser. Heat may be supplied by either steam or an independent hot-water heater. There are a number of different makes of tank heaters on the market.

The amount of water supply for the private system has not been stated, because this is really a matter of judgment and should be



CONDITIONING COTTON WITH ALL SURROUNDINGS READY TO CONTRIBUTE TO A CONFLAGRATION.

Note the wood platform covered with cotton and extending directly to the railway siding and buildings.



THOUSANDS OF BALES OF COTTON AND THE COMPRESS PLANT ALL SUBJECT TO A SINGLE FIRE.

When such an amount of cotton must be assembled in the open, it should be divided into lots of from 3,000 to 5,000 bales with these lots separated by two hundred feet clear space.

decided after consideration of the exact character of the supplies and the general hazard. Obviously, a fire-resistive plant well sprinklered would not need so great a supply of water as a plant of the semislow-burning, or wood-end type. While there are general rules in use for determining the supply required, it is not thought best to enter into a detailed discussion of them. The warehousemen should govern this question in detail with the insurance rating bureau having supervision before placing a contract for equipment.

SIGNALING SYSTEMS.

Signaling systems include any devices, both manual and automatic, for transmitting an alarm of fire.

The automatic sprinkler alarm referred to under that heading is especially well adapted to the cotton warehouse, and, generally, is the only such device that is required. Where this includes the electric type of alarm (either alone or in addition to the water motor alarm) the connection should be extended to the city fire department if such is available. This may be done by making a connection with the nearest city alarm box, though it is desirable that the connection be extended direct to the city fire department headquarters. This connection is valuable even in very small towns. A system of fire-alarm boxes is needed for large warehouses, but the expense is not justified for the plant of average size.

There are various automatic signaling systems on the market, but for the cotton warehouse the automatic sprinkler fulfills this service with entire satisfaction.

It is worthy of note that any electric signaling system, including the electric sprinkler alarm, may be used to close automatic fire doors when they are equipped with an electric release box.

PROTECTION AGAINST LIGHTNING.

Warehouses located in rural districts or in a locality subject to severe electrical storms should be protected against this source of fire, by adequate rodding. The "iron-clad" buildings are subject to the least hazard in this respect if the metal covering is thoroughly grounded. This may be accomplished by the gutter conductors where these discharge into cast-iron drain pipes extending well below the surface and into soil which is constantly moist.[1]

---

[1] Information on this subject, together with specifications for various types of installation, is contained in Farmers' Bulletin No. 842: Modern Methods of Protection Against Lightning, which may be obtained free of charge from the Division of Publication, U. S. Department of Agriculture. See also Suggestions for Protection Against Lightning recommended by the National Fire Protection Association.

WATCHMAN SERVICE.

Watchman service is an asset of variable value. The reliable service of one or more alert and able-bodied watchmen should be provided for plants of any considerable size. This is a form of protection which may be worth very much or nothing, depending on the character and duties of the watchmen. The regular tour of the watchman should be assured by well-distributed watch stations and a recording clock. The watch stations should be so distributed that in visiting them in sequence every part of the plant can be viewed. The equipment may consist of a portable watchman's clock carried by the watchman. The clock provides a specially ruled paper dial which is punched by the keys contained in and securely attached to the different watch station boxes. The paper dial is not otherwise accessible to the watchman. These paper disks are removed daily and filed in the office, thus effecting a record of the time at which the stations were visited. This form of equipment and service is adapted to most warehouses.

Large plants should be equipped with the central station watch service. In this case the recording clock is located at the watch office and the record of reports is punched on a paper tape. The watch stations provide a signaling mechanism electrically connected to the central station. When the watchman turns a key the number of this station together with the hour is registered upon the tape record at the watch office. If the signal is not given at or soon after the schedule time some one from the office is sent to the box to investigate the delinquency. In case any watchman on his rounds discovers fire, he uses this same station for turning in an alarm, which is transmitted to and automatically registered at the central watch office. The wachman then gives his attention to the fire, and is assured of prompt assistance directed from the watch office, while the other watchmen not otherwise directed continue their rounds.

Any system of watch service should be based upon a regular schedule, or tour, for the watchman, prepared by some one who has a knowledge of fire protective service. Insurance bureaus are glad to render this assistance. The interval set between visits of the watchman depends upon the general hazard, but should not exceed half an hour.

PRIVATE FIRE BRIGADE.

Organization for systematic team work in dealing with a fire should not be neglected. Years may pass without even an alarm, but this is not a good reason for not training employees of the plant as a private fire brigade. Each individual should understand fully the use of all fire protective equipment and the proper procedure in case of fire. Some firms have found it an advantage to pay men on the fire team a small bonus. For an ordinary business it is necessary to have all the force on the teams, while for a large plant the selection of men for the work may be such as to make the place sought after by the employees. The essential features are that the men be drilled sufficiently and be paid an amount that will make them feel that the work is of importance. It may be well to make this payment monthly, and separate from the regular wages, in order that it may be recognized as a distinct bonus for extra work. The organization of the fire brigade should be along military lines with distinct recognition of authority. The details of course, must be suited to the size of the plant. Valuable suggestions for the organization may be obtained from the National Board of Fire Underwriters, New York City, from the National Fire Protection Association, Boston, Mass., Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass., or insurance companies. These publications may be secured upon request.

PRECAUTIONS AGAINST FIRE.

Even though construction and fire protective equipment is the best there remains the need for careful administration on the part of the management. The first requisite is that responsibility be fixed upon some one individual as to proper upkeep and orderliness of the whole plant.

All buildings should be kept in good repair, giving special attention to doors, roof openings, and fire breaks in platforms and sheds.

Water barrels and pails should be kept well filled, and in winter water should be treated to prevent freezing. All sources of water supply must be under observation that the tanks may be kept filled, pumps in good order, power maintained, and valves properly set. All mechanical equipment must be tested frequently; the hose should be tested occasionally under full-water pressure, then properly dried and coiled on the racks.

The management should see that the automatic sprinkler system is in good order, taking care that sprinkler heads are not "loaded" by a coating of whitewash or paint, that there are no valves closed, and, in the case of a dry-pipe system, that there is no water columning of the dry valve—due to excess water leaking past it and into the riser—and that the valve is in good working order. Eaves sprinklers on a wet-pipe system must be drained in cold weather. A number of extra sprinkler heads facilitate ready repairs.

All water supply valves should be open and sealed or strapped. The strap should be secured with a padlock so that the strap can be cut in an emergency but will not be tampered with ordinarily. Permission for closing a valve must be obtained from the person responsible for fire protection whenever this is possible. In any case the closed valve should be tagged conspicuously and a notice of the fact kept filed in the office during the entire time such valve is closed, in so far as this is practicable. Never have both sources of water supply cut off overnight; when making repairs, provide a temporary connection.

Fire doors should be closed at night and when not in use. There should be occasional tests of sensitive closing devices for fire doors and examination to see that fusible links are not painted or whitewashed.

Oily waste should not be allowed to accumulate, as it is a potent source of fire. It should be placed in a closed metal can kept near the press for such waste. There should be no loose cotton on floors or platforms. Conspicuous signs reading "No smoking" must be posted and the order strictly enforced. No loose matches may be permitted about the warehouses or premises. The premises must be kept cleared of dry grass, weeds, and all kinds of loose rubbish. If buildings or platforms are elevated, the space under them should be closed in to prevent such accumulations under them.

The management should avoid leaving cotton exposed overnight as far as possible. When storage in open yards is unavoidable, the bales should be separated into units not exceeding 3,000 to 5,000 bales with a clear space of 200 feet or more between such units. The use of fire walls for dividing such areas is of little value unless the area is covered by a noninflammable roof as fire brands and sparks will be blown over the wall.

Employees should follow up passing locomotives near areas of unprotected cotton to see that no sparks have started small blazes. All ashes which are removed from boilers or heaters should be wet thoroughly. The watch service should be checked up frequently and made very thorough.

SELECTION OF THE WAREHOUSE DESIGN.

Selection of the design, type of construction, and forms of fire protection for the warehouse must be made with a knowledge of the business conditions existing and to be anticipated. This involves the answer to five questions: (1) During what portion of the year will the warehouse normally be filled to capacity and during what portion of the year will the capacity be only partially utilized and to what extent? (2) Will the deposits of cotton be withdrawn in large or small lots—by individual bale orders or in solid blocks? (3) What will be the number of yearly "turnovers," or changes in the individual bales stored? (4) Will cotton be stored in the compressed or flat form of bale? (5) How long will the present business conditions exist and what prospect is there of a materially enlarged business?

If, in answer to question 1, it is determined that the warehouse will be filled to capacity during a few months only as is generally the case of a warehouse which stores for farmers, it is evident that a low investment cost is essential. Hence the semislow-burning type of construction should be used unless the surroundings or the size and congestion of the warehouse entail a serious fire hazard, in which case the slow-burning type of building should be adopted. If, in answer to question 2, it is found that cotton will be handled in small lots or by selection of individual bales, the cotton should not be piled, but should be stored one bale high on end, the storage arrangement being vitally connected with the cost of handling. This means that economy of investment and avoidance of over-expansion of the plant both are favorable to a building of two or three stories. The influence of question 3 will depend upon current local practice among storers of cotton. As to question 4 regarding cotton storage in flat or compressed form, this determines the amount of cotton which can be placed in a single compartment subject to one fire and hence influences the size of compartment advisable. The last question of expected future conditions must determine the planning with a view to future extension of the plant and permanency of the structures.

If the solution of question 1 indicates that the warehouse will be filled to its normal capacity for a large portion of the year, as may be the case of a warehouse storing for cotton dealers, the item of investment cost is of less importance and is superseded by the possible cost of insurance, of labor, and of depreciation charges. In such case, determining whether cotton will be handled in large or small lots, with or without regard to the characteristics of the individual bale, is of foremost importance. Coordinate with this factor is that of the number of "turnovers." Closely associated is the question of whether cotton will be stored flat or compressed. In general, the labor cost should be given the greatest consideration, because it is the only factor which increases with the volume of business—the end aimed at. Hence, piling cotton can not be tolerated, except for a small portion of the season. This means that unless cotton is stored compressed the multiple story design generally must be adopted. If cotton is stored compressed a single tier of bales on end filling a single story compartment economically proportioned will result in a value as great as should be subjected to a single possible fire. If cotton is stored uncompressed the contents of three such floors of equal area each, if sprinklered, would not be a greater hazard, even with the slow-burning type of construction.

But for all buildings of more than one story, fire-resistive construction is preferable.

The port warehouse, which handles cotton in large blocks, should not find any serious objection to piling cotton provided it is held in storage for a considerable time. The port warehouse may require a combination of building designs to meet different forms of business.

The cotton-mill warehouse requires convenience of handling to a certain degree, but it is overshadowed by the importance of the maximum of protection from fire. Hence the choice is usually between the low one-story wood-end building, if a small quantity of cotton is stored, and the multiple-story building of fire-resistive design if a large amount of cotton is kept on hand. For the mill that handles cotton waste or inferior cotton in quantity favorable consideration may be given to the wood-end building having a single high story with cotton piled.

In general, one-story buildings for small plants may be of the semi-slow-burning, or wood-end, type of construction, but for large plants or for plants having an exposure from the parallel buildings or from adjacent property the slow-burning design with openings fully protected should be used. From the standpoint of actual fire hazard, the best slow-burning construction with a tar-and-gravel roof is equally as good as the fire-resistive construction for the one-story building. However, there is a physiological advantage in the fire-resistive construction, and the depreciation charges are less. For multiple-story buildings fire-resistive construction should be used whenever possible, and always for buildings of from four to six stories in height. For buildings of less than four stories and sprinklered, slow-burning construction is fairly satisfactory, and for buildings of two stories the feasible construction is often the semi-slow burning or " wood-end."

It should be remembered in comparing the cost of timber and reinforced concrete floors that often the cost is practically the same for floors to carry heavy loads, while the timber construction is very much cheaper for floors designed for very light loads, particularly if the span, or spacing of supports, is long. Also, the flat-slab designs for reinforced concrete, while always desirable, are more economical as compared with the beams system when the slab is continuous through division fire walls, when the span is regular and not too great and when the loads to be carried are heavy. It is apparent that these considerations are closely related to the density and arrangement of bales stored.

Fire protective equipment should be considered of fundamental importance, and complete protection should be provided for all large warehouses.

APPENDIX.

STANDARD WAREHOUSE PLANS.

The following plans are given as a basis for warehouse planning. The notations on the plans are specific when they can be without causing lack of economy when the plans are applied over a wide range of country. The plans themselves permit some flexibility which may be necessary for their economical adaptation to the site.

Each drawing shows an end compartment and an intermediate compartment. Compartments may be combined in any number to a maximum of 700 feet length for a single building, unless local conditions demand a shorter length.

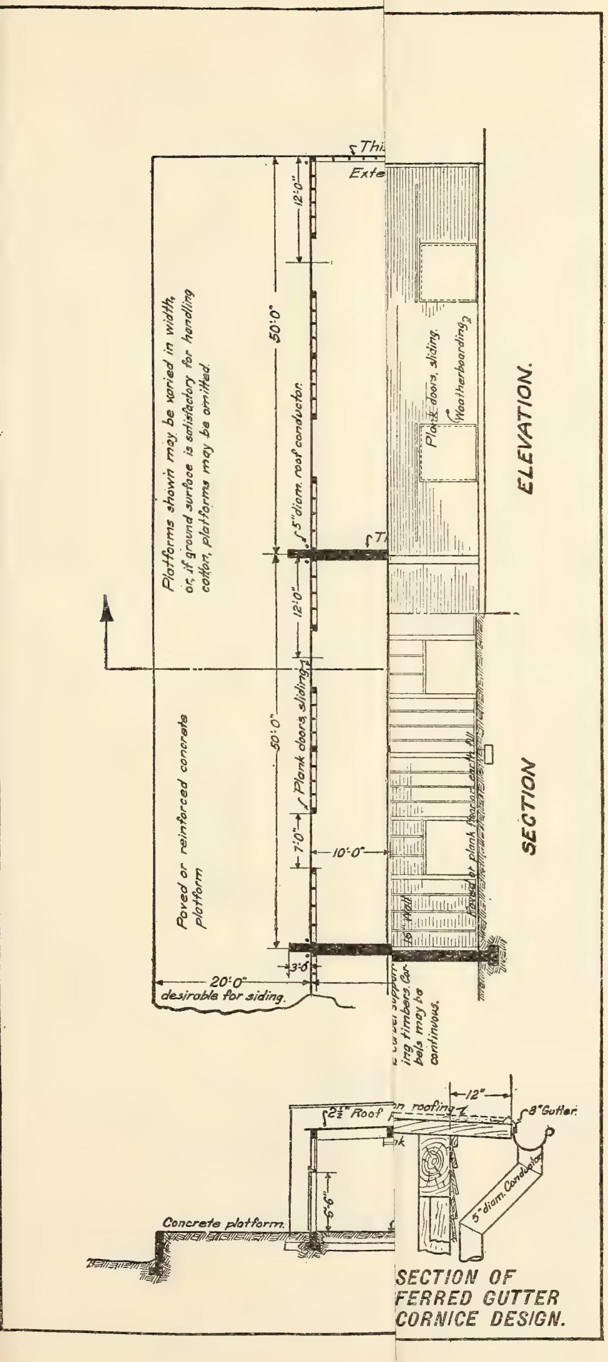
As pointed out in the bulletin, increased capacity above that shown for compartments may be provided by either increased area or height, with provision made for later subdividing of the compartment by an additional fire wall or an intermediate floor. The plans should be followed in detail wherever possible.

Contracts should not be let merely upon the plans shown here, as the variations permitted by the information on the drawings should be eliminated, and comprehensive specifications suited to local conditions should be made a part of such contract. Moreover, the plans and layout of the plant, including fire protection, should be submitted for approval to the insurance rating bureau having supervision in order that the owner may secure advantageous insurance rates. A competent engineer should be employed and a request for detailed drawings sent to the Bureau of Markets, United States Department of Agriculture, Washington, D. C.

The last drawing of the appendix shows a variety of arrangements for cotton storage in different floors and the number of bales which the arrangement provides for. The arrangement is based upon the liberal allowance of 30 by 48 by 56 inches for the American bale uncompressed. If the bales are compressed to ordinary density, 50 per cent more bales can be stored, or 75 per cent more if compressed to high density. Isles shown are a minimum width of 4 feet. In the case of compartments having "wood-end" walls cotton should not be stored within 4 feet of the frame wall, and hence a few less bales than indicated can be stored. The number and preferred location of water barrels required is also shown on the diagrams.

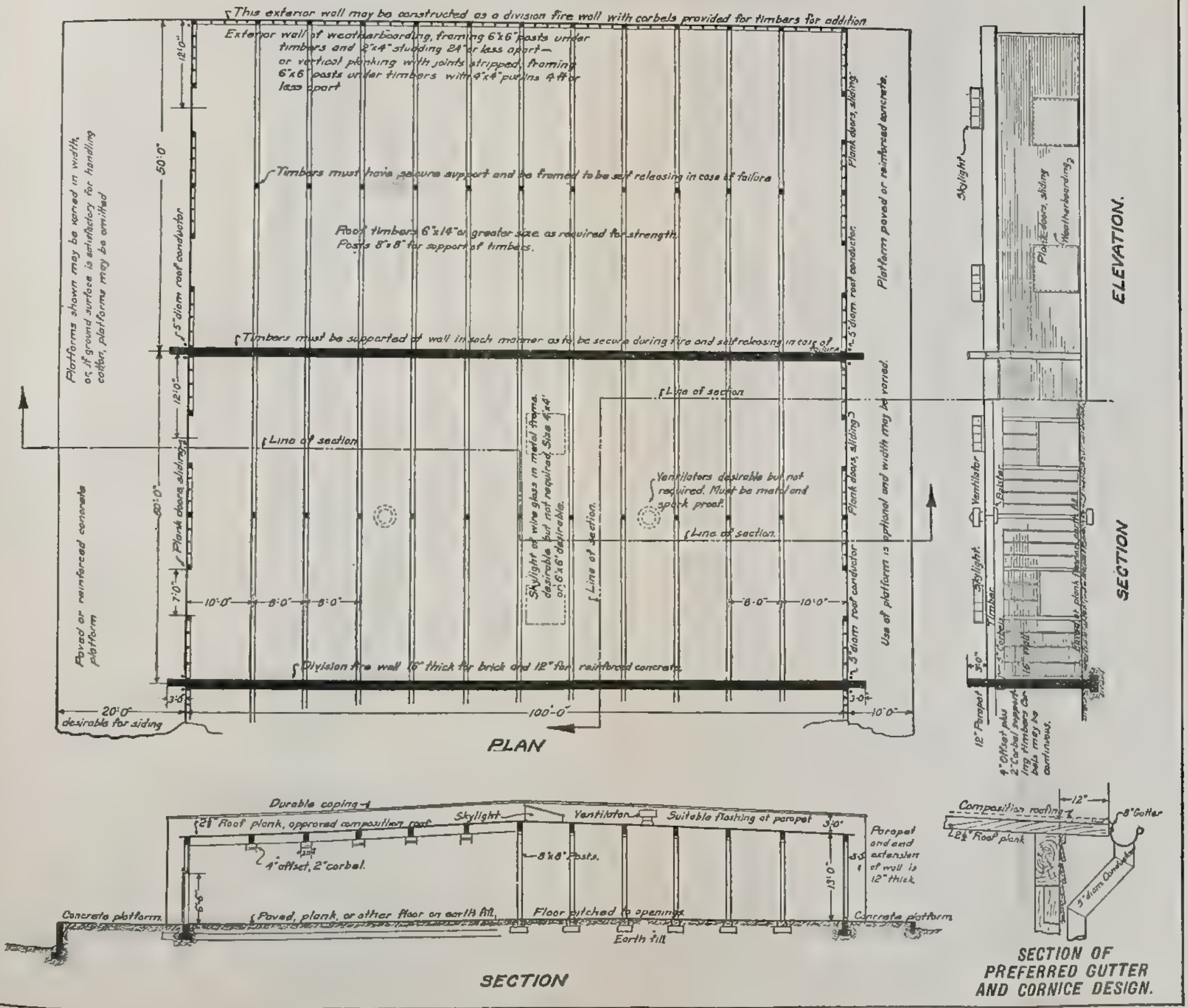
ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
50 CENTS PER COPY
▽

PLAN W1A.

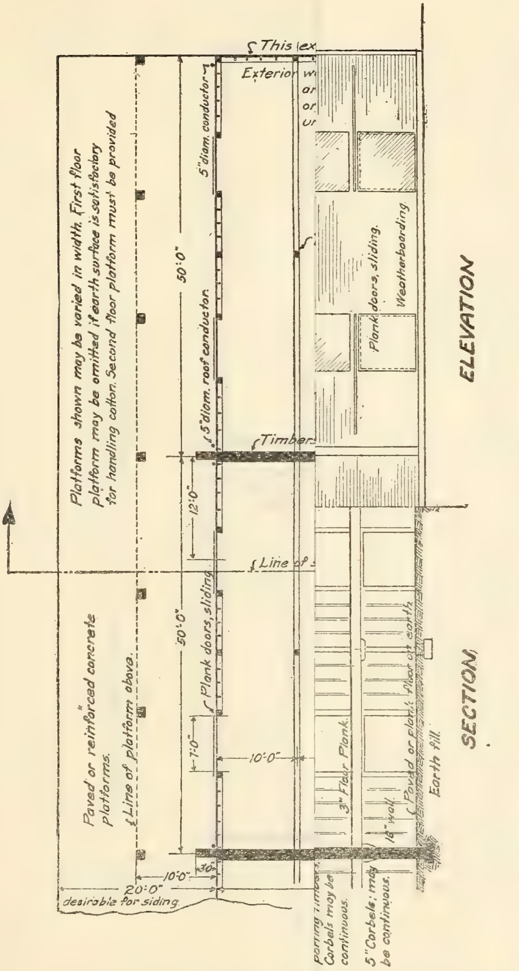

Platforms shown may be varied in width, or, if ground surface is satisfactory for handling cotton, platforms may be omitted.
Paved or reinforced concrete platform
20'-0" desirable for siding.
3'-6"
50'-0"
12'-0"
50'-0"
12'-0"
7'-0"
10'-0"
5" diam. roof conductor.
Plank doors, sliding
Plank doors, sliding.
Weatherboarding
Thi
Exte
Th
16" wall
Paved or plank floor on earth fill
ing timbers. Cor-bels may be continuous.
ELEVATION.
SECTION.
Concrete platform.
2½" Roof
roofing
12"
8" Gutter.
5" diam. Conductor
5'-6"
SECTION OF
FERRED GUTTER
CORNICE DESIGN.

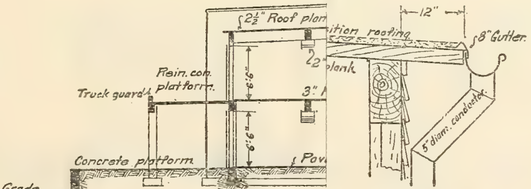
CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.

It should be adapted and amplified by detailed drawings and specifications

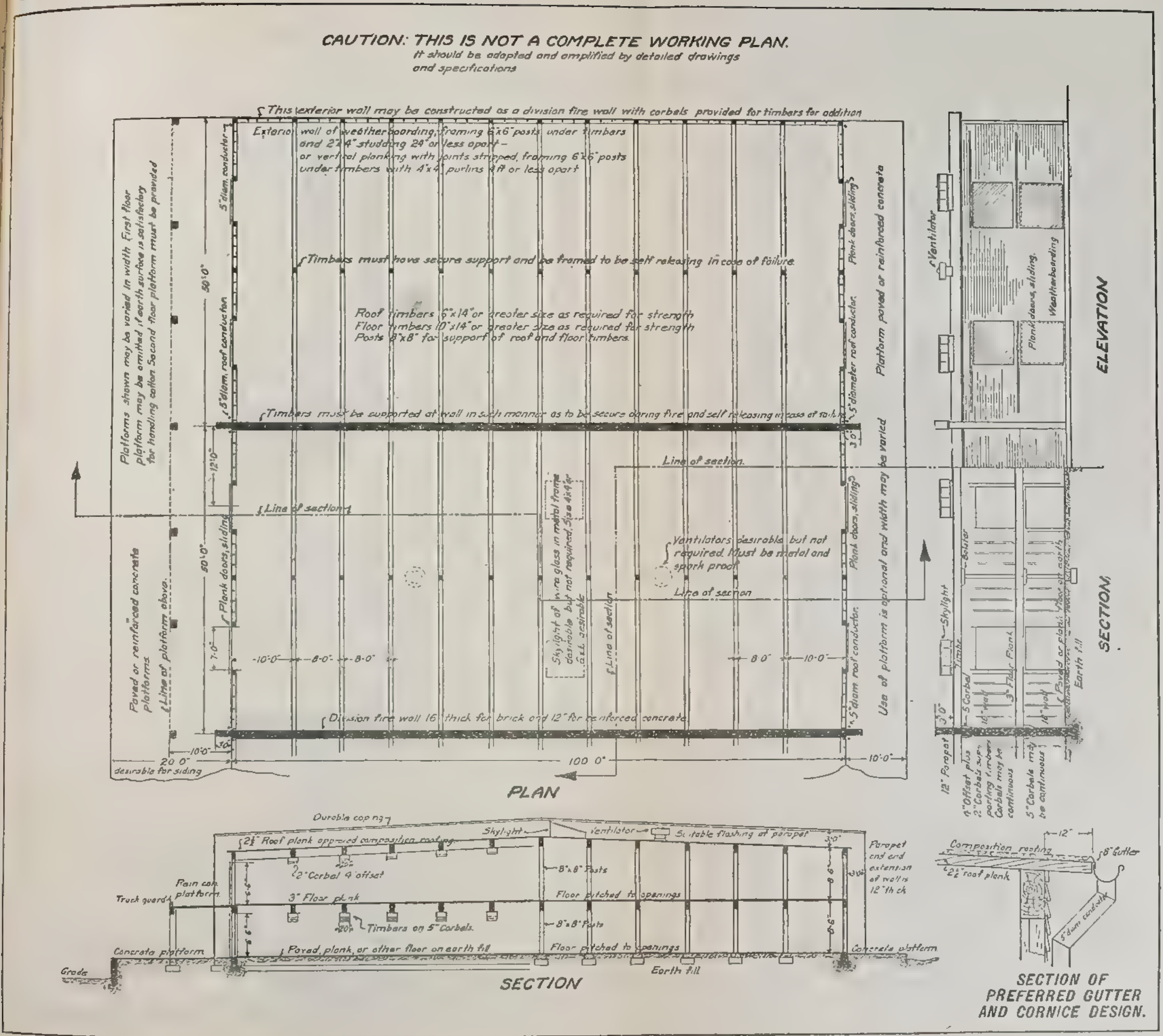

This exterior wall may be constructed as a division fire wall with corbels provided for timbers for addition
Exterior wall of weatherboarding, framing 6"x6" posts under timbers and 2"x4" studding 24" or less apart— or vertical planking with joints stripped, framing 6"x6" posts under timbers with 4"x4" purlins 4 ft or less apart
Timbers must have secure support and be framed to be self releasing in case of failure
Roof timbers 6"x14" or greater size as required for strength. Posts 8"x8" for support of timbers.
Timbers must be supported at wall in such manner as to be secure during fire and self releasing in case of failure
Platforms shown may be varied in width, or, if ground surface is satisfactory for handling cotton, platforms may be omitted
5" diam roof conductor
12'0"
50'0"
80'0"
7'0"
3'0"
Plank doors, sliding
Line of section
Skylight of wire glass in metal frame, desirable but not required. Size 4'x4' or 6'x6' desirable.
Line of section
Ventilators desirable but not required. Must be metal and spark proof.
Line of section
Paved or reinforced concrete platform
10'0"
8'0"
8'0"
8'0"
10'0"
Division fire wall 16" thick for brick and 12" for reinforced concrete
20'0" desirable for siding
100'0"
3'0"
10'0"
Plank doors, sliding
5" diam roof conductor
Plank doors, sliding
5" diam roof conductor
Platform paved or reinforced concrete.
Use of platform is optional and width may be varied.
PLAN
Skylight
Plank doors, sliding
Weatherboarding
ELEVATION.
Ventilator
Bolster
Skylight
Skylight
Timber
Corbels
16" Wall
Paved or plank floor on earth fill
3'0"
12" Parapet
4" Offset plus 2" Corbel supporting timbers Corbels may be continuous.
SECTION
Durable coping
2½" Roof plank, approved composition roof
Skylight
Ventilator
Suitable flashing at parapet
3'0"
4" offset, 2" corbel.
8"x8" Posts.
9'6"
13'0"
3'6"
Parapet and end extension of wall is 12" thick
Concrete platform.
Paved, plank, or other floor on earth fill.
Floor pitched to openings
Earth fill
Concrete platform
SECTION
Composition roofing
12"
8" Gutter
2½" Roof plank
5" diam Conductor
SECTION OF PREFERRED GUTTER AND CORNICE DESIGN.

SEMISLOW-BURNING WAREHOUSE DESIGN W1A.

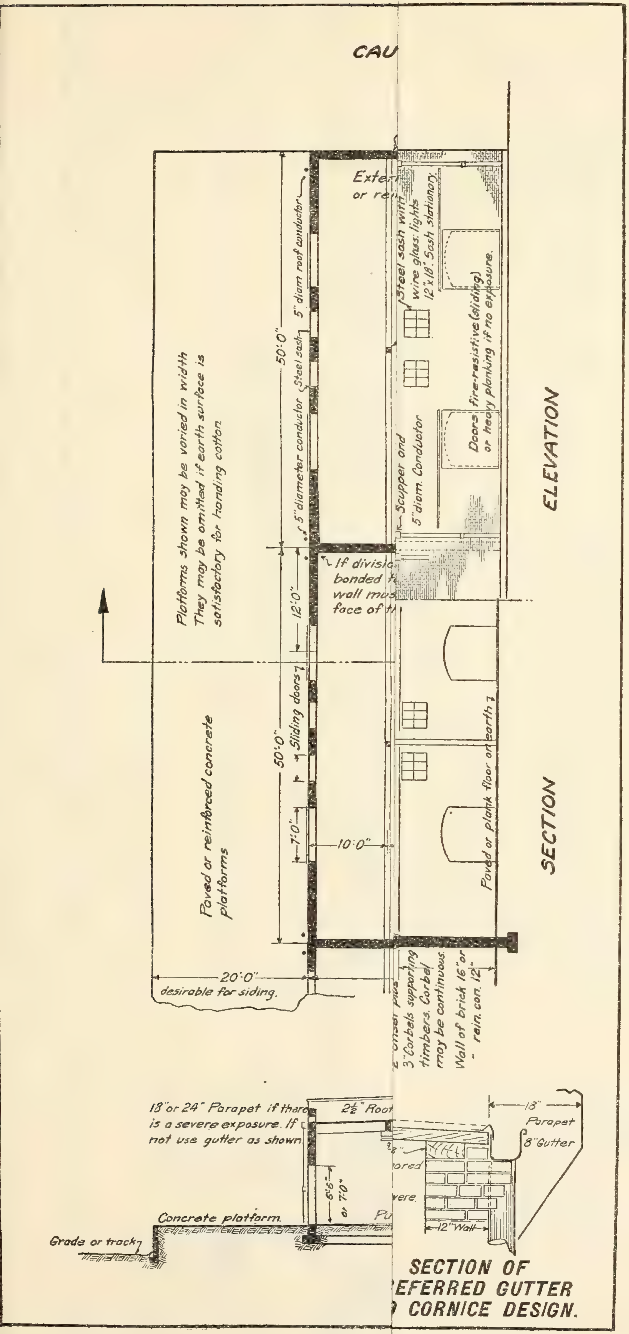

This ex
Exterior w
or
or
Ur
5" diam. conductor
Platforms shown may be varied in width. First floor platform may be omitted if earth surface is satisfactory for handling cotton. Second floor platform must be provided
50'0"
5" diam. roof conductor
Timbers
12'0"
Line of s
50'0"
Plank doors, sliding
Paved or reinforced concrete platforms.
Line of platform above.
7'0"
10'0"
10'0"
30"
20'0"
desirable for siding
Plank doors, sliding.
Weatherboarding.
ELEVATION
3" Floor Plank.
18" wall
Paved or plank floor on earth
Earth fill.
SECTION
porting timbers. Corbels may be continuous.
5" Corbels; may be continuous.

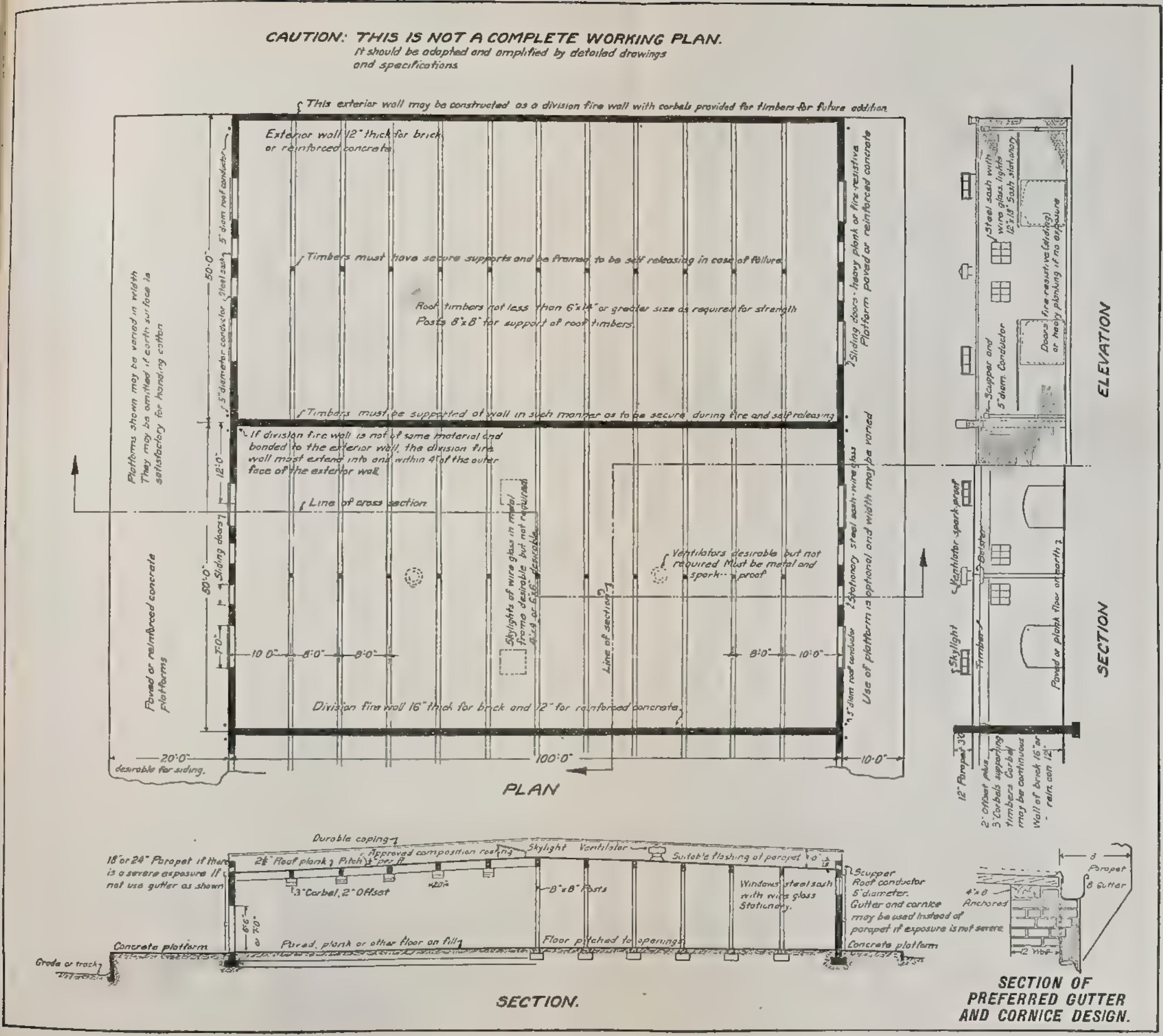


SECTION OF PREFERRED GUTTER ND CORNICE DESIGN.


CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adapted and amplified by detailed drawings and specifications
This exterior wall may be constructed as a division fire wall with corbels provided for timbers for addition
Exterior wall of weatherboarding, framing 6"x6" posts under timbers and 2"x4" studding 24" or less apart – or vertical planking with joints stripped, framing 6"x6" posts under timbers with 4"x4" purlins 4 ft or less apart
Timbers must have secure support and be framed to be self releasing in case of failure.
Roof timbers 6"x14" or greater size as required for strength
Floor timbers 10"x14" or greater size as required for strength
Posts 8"x8" for support of roof and floor timbers.
Timbers must be supported at wall in such manner as to be secure during fire and self releasing in case of failure
Platforms shown may be varied in width First floor platform may be omitted if earth surface is satisfactory for handling cotton Second floor platform must be provided
5" diam. conductor
5" diam. roof conductor
50'0"
50'0"
12'0"
7'0"
Plank doors, sliding
Line of section
Line of section.
Line of section
Line of section
Skylight of wire glass in metal frame desirable but not required. Size 4'x4' or 6'x6' desirable
Ventilators desirable but not required. Must be metal and spark proof
Plank doors, sliding
5" diameter roof conductor
5" diam roof conductor.
Platform paved or reinforced concrete
Use of platform is optional and width may be varied
3'0"
Paved or reinforced concrete platforms
Line of platform above.
-10'0"- -8'0"- -8'0"-
-8'0"- -10'0"-
Division fire wall 16" thick for brick and 12" for reinforced concrete
10'0"
3'0"
20'0"
desirable for siding
100'0"
10'0"
PLAN
Ventilator
Plank doors, sliding.
Weatherboarding
ELEVATION
Skylight
Bolster
Timber
5" Corbel
16" Wall
3" Floor Plank
16" Wall
Paved or plank floor on earth
Earth fill
3'0"
SECTION.
12" Parapet
4" Offset plus 2" Corbels supporting timbers Corbels may be continuous
5" Corbels may be continuous
Durable coping
2½" Roof plank approved composition roofing
Skylight
Ventilator
Suitable flashing at parapet
3'0"
Parapet end and extension of walls 12" thick
2" Corbel 4" offset
8"x8" Posts
Rain coat platform
Truck guard
3" Floor plank
Floor pitched to openings
8'6"
Timbers on 5" Corbels.
20"
8"x8" Posts
9'6"
Concrete platform
Paved, plank, or other floor on earth fill
Floor pitched to openings
Concrete platform
Grade
Earth fill
SECTION
Composition roofing
12"
6" Gutter
2½" roof plank
5" diam conductor
SECTION OF PREFERRED GUTTER AND CORNICE DESIGN.

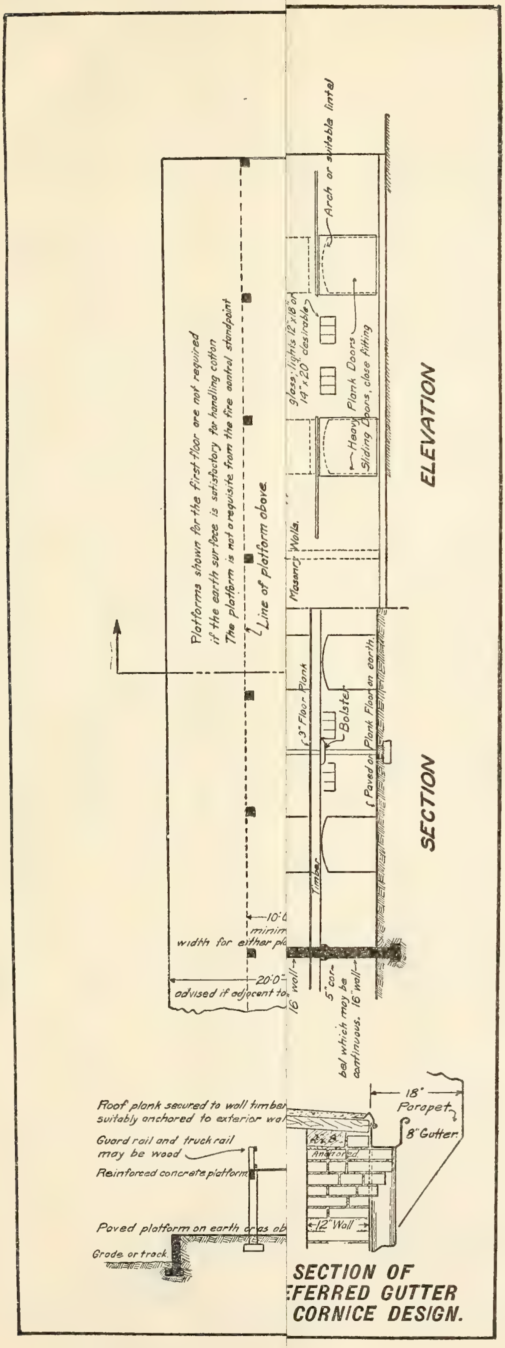
SEMISLOW-BURNING WAREHOUSE DESIGN W2A.

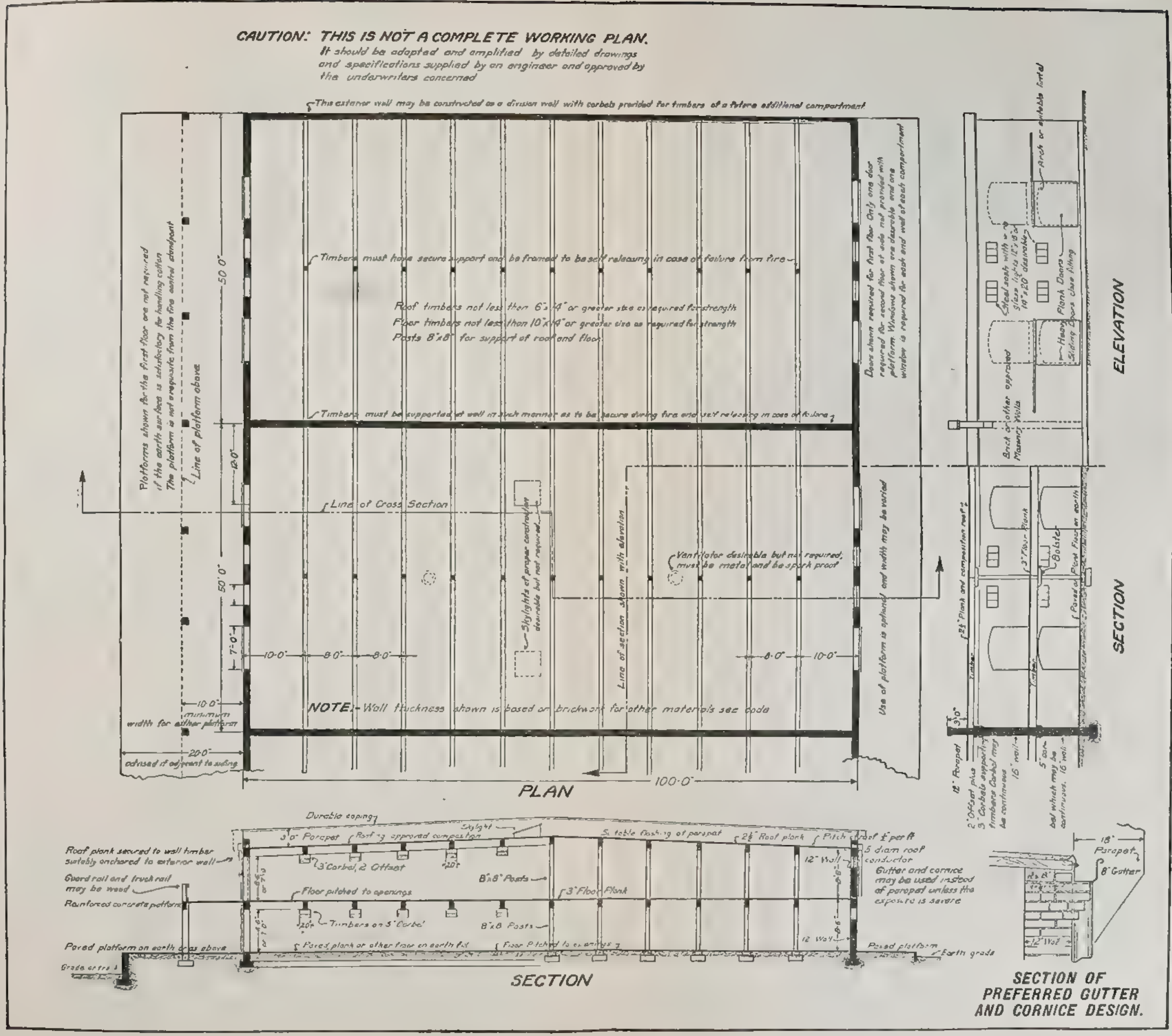

CAU
Exter
or rei
Steel sash with wire glass: lights 12"x18". Sash stationary.
5" diam. roof conductor
Steel sash
50'-0"
5" diameter conductor
Doors fire-resistive (sliding) or heavy planking if no exposure.
Scupper and 5" diam. Conductor
ELEVATION
Platforms shown may be varied in width
They may be omitted if earth surface is satisfactory for handing cotton.
If divisio
bonded t
wall mus
face of th
12'-0"
Sliding doors
50'-0"
7'-0"
10'-0"
Paved or reinforced concrete platforms
Paved or plank floor or earth
SECTION
20'-0"
desirable for siding.
2" offset plus 3" Corbels supporting timbers. Corbel may be continuous.
Wall of brick 16" or " rein. con. 12"
18" or 24" Parapet if there is a severe exposure. If not use gutter as shown
2½" Roof
ored
vere.
6'-6" or 7'-0"
Concrete platform.
Grade or track
18"
Parapet
8" Gutter
12" Wall
SECTION OF
EFERRED GUTTER
CORNICE DESIGN.


CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adopted and amplified by detailed drawings and specifications
This exterior wall may be constructed as a division fire wall with corbels provided for timbers for future addition
Exterior wall 12" thick for brick or reinforced concrete
Timbers must have secure supports and be framed to be self releasing in case of failure
Roof timbers not less than 6"x14" or greater size as required for strength
Posts 8"x8" for support of roof timbers
Timbers must be supported at wall in such manner as to be secure during fire and self releasing
If division fire wall is not of same material and bonded to the exterior wall, the division fire wall must extend into and within 4" of the outer face of the exterior wall
Line of cross section
Skylights of wire glass in metal frame desirable but not required 4'x4' or 6'x6' desirable
Ventilators desirable but not required Must be metal and spark proof
Line of section
Division fire wall 16" thick for brick and 12" for reinforced concrete
Platforms shown may be varied in width They may be omitted if earth surface is satisfactory for handing cotton
Paved or reinforced concrete platforms
5" diam roof conductor
Steel sash
5" diameter conductor
Sliding doors
50'-0"
12'-0"
50'-0"
7'-0"
10'0"
8'0"
8'0"
8'0"
10'0"
20'-0"
desirable for siding.
100'-0"
10'-0"
Sliding doors - heavy plank or fire resistive
Platform paved or reinforced concrete
Stationary steel sash - wire glass
Use of platform is optional and width may be varied
5" diam roof conductor
PLAN
Steel sash with wire glass, lights 12"x18" Sash stationary
Doors fire resistive (sliding) or heavy planking if no exposure
Scupper and 5" diam. Conductor
ELEVATION
Ventilator spark proof
Bolster
Skylight
Timbers
Paved or plank floor on earth
SECTION
12" Parapet 3'0"
2" Offset plus 3" Corbels supporting timbers Corbel may be continuous
Wall of brick 16" or rein. con 12"
Durable coping
18" or 24" Parapet if there is a severe exposure If not use gutter as shown
2½" Roof plank
Pitch ¼" per ft
Approved composition roofing
Skylight
Ventilator
Suitable flashing of parapet
3" Corbel, 2" Offset
8"x8" Posts
Windows steel sash with wire glass Stationary.
Scupper
Roof conductor 5" diameter.
Gutter and cornice may be used instead of parapet if exposure is not severe.
6'-6" or 7'-0"
Concrete platform
Grade or track
Paved, plank or other floor on fill
Floor pitched to openings
Concrete platform
SECTION.
8
Parapet
8 Gutter
4"x8" Anchored
12
SECTION OF PREFERRED GUTTER AND CORNICE DESIGN.

SLOW-BURNING WAREHOUSE DESIGN S1A.

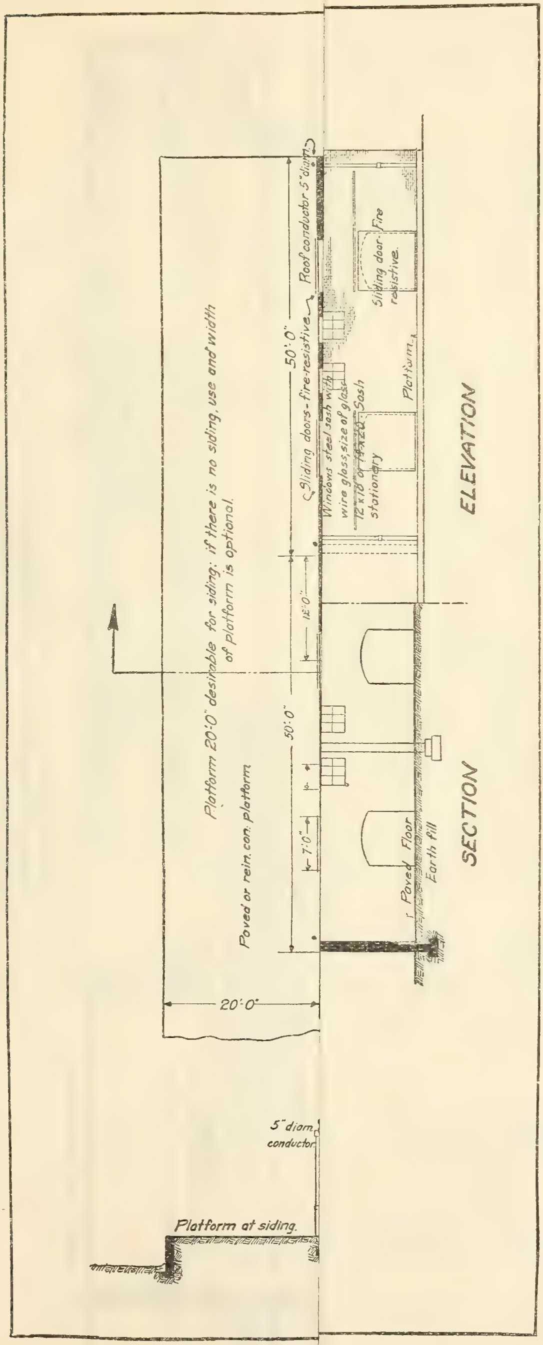
PLAN S2A.

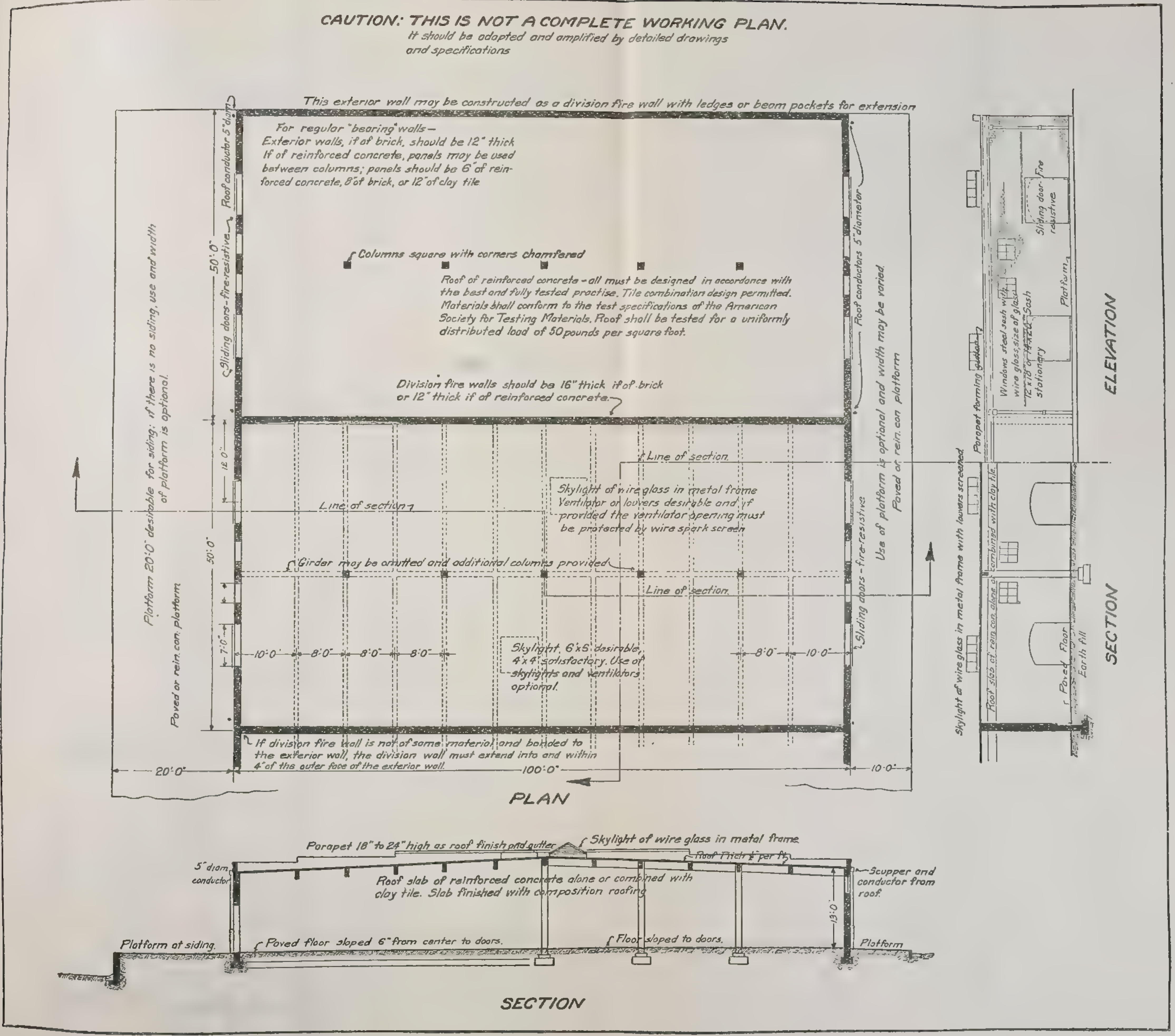

Platforms shown for the first floor are not required if the earth surface is satisfactory for handling cotton
The platform is not a requisite from the fire control standpoint
Line of platform above
10'-0
minim
width for either pl
20'-0
advised if adjacent to
Arch or suitable lintel
glass; lights 12"x18" or 14"x20" desirable
Plank Doors
Heavy Sliding Doors, close fitting
Masonry Walls
ELEVATION
3" Floor Plank
Bolster
Paved or Plank Floor on earth.
Timber
16" wall
5" corbel which may be continuous. 16" wall
SECTION
Roof plank secured to wall timber suitably anchored to exterior wal
Guard rail and truck rail may be wood
Reinforced concrete platform
Paved platform on earth or as ab
Grade or track
18"
Parapet
8" Gutter
4"x8"
Anchored
12" Wall
SECTION OF
FERRED GUTTER
CORNICE DESIGN.


CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adapted and amplified by detailed drawings and specifications supplied by an engineer and approved by the underwriters concerned
This exterior wall may be constructed as a division wall with corbels provided for timbers of a future additional compartment
Timbers must have secure support and be framed to be self releasing in case of failure from fire
Roof timbers not less than 6"x14" or greater size as required for strength
Floor timbers not less than 10"x14" or greater size as required for strength
Posts 8"x8" for support of roof and floor
Timbers must be supported at wall in such manner as to be secure during fire and self releasing in case of failure
Platforms shown for the first floor are not required if the earth surface is satisfactory for handling cotton The platform is not a requisite from the fire control standpoint
Line of platform above
50'0"
12'0"
50'0"
7'0"
Line of Cross Section
Skylights of proper construction desirable but not required
Line of section shown with elevation
Ventilator desirable but not required; must be metal and be spark proof
Doors shown required for first floor Only one door required for second floor at side not provided with platform. Windows shown are desirable and one window is required for each end wall of each compartment
Use of platform is optional and width may be varied
10'0"
8'0"
8'0"
8'0"
10'0"
NOTE:- Wall thickness shown is based on brickwork for other materials see code
10'0" minimum width for either platform
20'0" advised if adjacent to siding
100'0"
PLAN
Arch or suitable lintel
Steel sash with wire glass lights 12"x18" or 14"x20" desirable
Plank Doors
Heavy Sliding Doors close fitting
Brick or other approved Masonry Walls
ELEVATION
2½" Plank and composition roof
3" Floor Plank
Bolster
Paved or Plank Floor on earth
Timber
Timber
3'0"
12" Parapet
2" Offset plus 3" Corbels supporting timbers Corbel may be continuous
16" wall
5" corbel which may be continuous.
16" wall
SECTION
Durable coping
Skylight
3'0" Parapet
Roofing approved composition
Suitable flashing of parapet
2½" Roof plank
Pitch of roof ¼" per ft
Roof plank secured to wall timber suitably anchored to exterior wall
5" diam roof conductor
3" Corbel, 2" Offset
20"
12" Wall
8'6" or 7'0"
8'6"
Gutter and cornice may be used instead of parapet unless the exposure is severe
8"x8" Posts
Guard rail and truck rail may be wood
Floor pitched to openings
3" Floor Plank
Reinforced concrete platform
20"
Timbers on 5" Corbel
8"x8" Posts
8'6" or 7'0"
8'6"
12" Wall
Paved platform on earth or as above
Paved plank or other floor on earth fill
Floor Pitched to openings
Paved platform
Earth grade
Grade or track
SECTION
18"
Parapet
8" Gutter
2"x8"
12" Wall
SECTION OF PREFERRED GUTTER AND CORNICE DESIGN.

SLOW-BURNING WAREHOUSE DESIGN S2A.

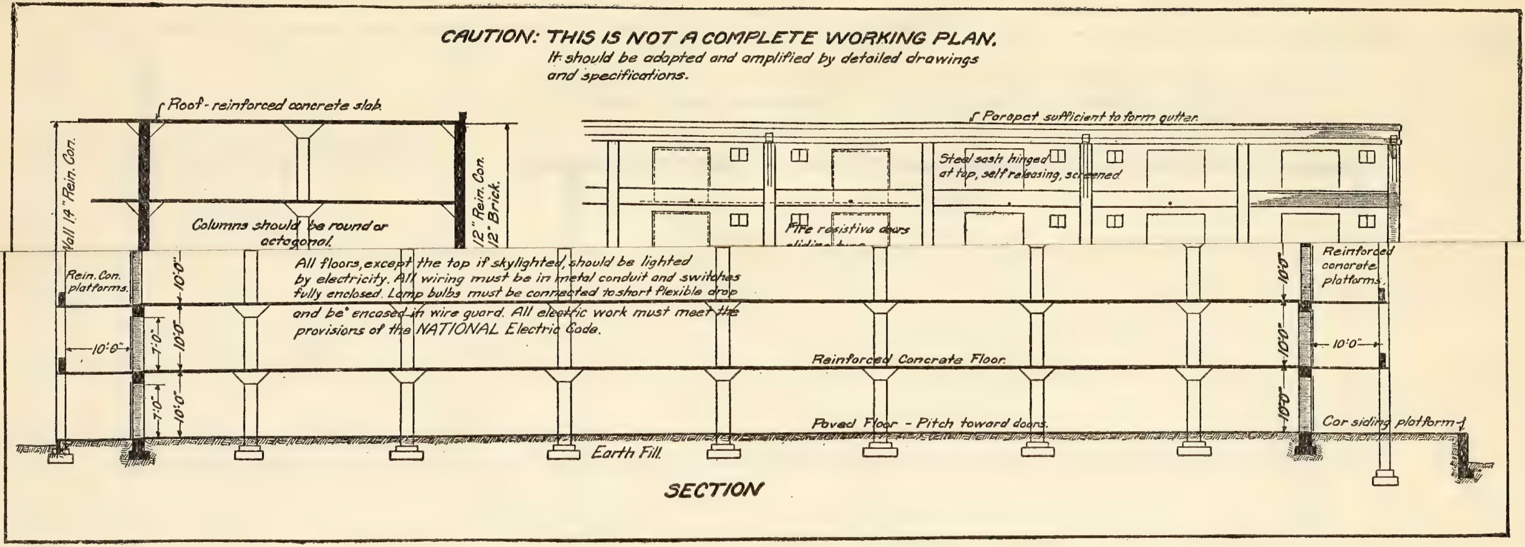
PLAN F1A.


Platform 20'0" desirable for siding: if there is no siding, use and width of platform is optional.
Paved or rein. con. platform
20'0"
50'0"
12'0"
50'0"
7'0"
Roof conductor 5" diam.
Sliding doors-fire-resistive
Windows steel sash with wire glass, size of glass 12x18 or 14x20. Sash stationary
Sliding door-Fire resistive.
Platform
ELEVATION
Paved Floor
Earth fill
SECTION
5" diam. conductor
Platform at siding.


CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adapted and amplified by detailed drawings and specifications
This exterior wall may be constructed as a division fire wall with ledges or beam pockets for extension
For regular "bearing" walls— Exterior walls, if of brick, should be 12" thick If of reinforced concrete, panels may be used between columns; panels should be 6" of reinforced concrete, 8" of brick, or 12" of clay tile
Columns square with corners chamfered
Roof of reinforced concrete - all must be designed in accordance with the best and fully tested practise. Tile combination design permitted. Materials shall conform to the test specifications of the American Society for Testing Materials. Roof shall be tested for a uniformly distributed load of 50 pounds per square foot.
Division fire walls should be 16" thick if of brick or 12" thick if of reinforced concrete.
Line of section
Skylight of wire glass in metal frame Ventilator or louvers desirable and if provided the ventilator opening must be protected by wire spark screen
Line of section
Girder may be omitted and additional columns provided
Line of section
Skylight, 6'x6' desirable, 4'x4' satisfactory. Use of skylights and ventilators optional.
If division fire wall is not of same material and bonded to the exterior wall, the division wall must extend into and within 4" of the outer face of the exterior wall.
Roof conductor 5" diam.
Sliding doors - fire-resistive
Platform 20'0" desirable for siding; if there is no siding, use and width of platform is optional.
Paved or rein. con. platform
Roof conductors 5" diameter
Sliding doors - fire-resistive
Use of platform is optional and width may be varied.
Paved or rein. con. platform
50'0"
12'0"
50'0"
7'0"
10'0"
8'0"
8'0"
8'0"
8'0"
10'0"
20'0"
100'0"
10'0"
PLAN
Parapet 18" to 24" high as roof finish and gutter
Skylight of wire glass in metal frame
Roof Pitch ¼" per ft.
5" diam. conductor
Roof slab of reinforced concrete alone or combined with clay tile. Slab finished with composition roofing
Scupper and conductor from roof.
13'0"
Platform at siding.
Paved floor sloped 6" from center to doors.
Floor sloped to doors.
Platform
SECTION
Parapet forming gutter
Windows steel sash with wire glass, size of glass 12"x18" or 14"x20" Sash stationary
Sliding door - Fire resistive
Platform
ELEVATION
Skylight of wire glass in metal frame with louvers screened.
Roof slab of rein. con. alone or combined with clay tile.
Paved Floor
Earth fill
SECTION

FIRE-RESISTIVE WAREHOUSE DESIGN F1A.

CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.



CAUTION: THIS IS NOT A COMPLETE WORKING PLAN.
It should be adapted and amplified by detailed drawings and specifications.

All floors, except the top if skylighted, should be lighted by electricity. All wiring must be in metal conduit and switches fully enclosed. Lamp bulbs must be connected to short flexible drop and be encased in wire guard. All electric work must meet the provisions of the NATIONAL Electric Code.

Roof - reinforced concrete slab.
Wall 14" Rein. Con.
12" Rein. Con.
12" Brick.
Columns should be round or octagonal.
Rein. Con. platforms.
10'0"
7'0"
10'0"
7'0"
10'0"
10'0"
Parapet sufficient to form gutter.
Steel sash hinged at top, self releasing, screened
Fire resistive doors
Reinforced concrete platforms.
10'0"
10'0"
10'0"
10'0"
Reinforced Concrete Floor.
Paved Floor - Pitch toward doors.
Car siding platform
Earth Fill.
SECTION

FIRE-RESISTIVE WAREHOUSE DESIGN F4A.

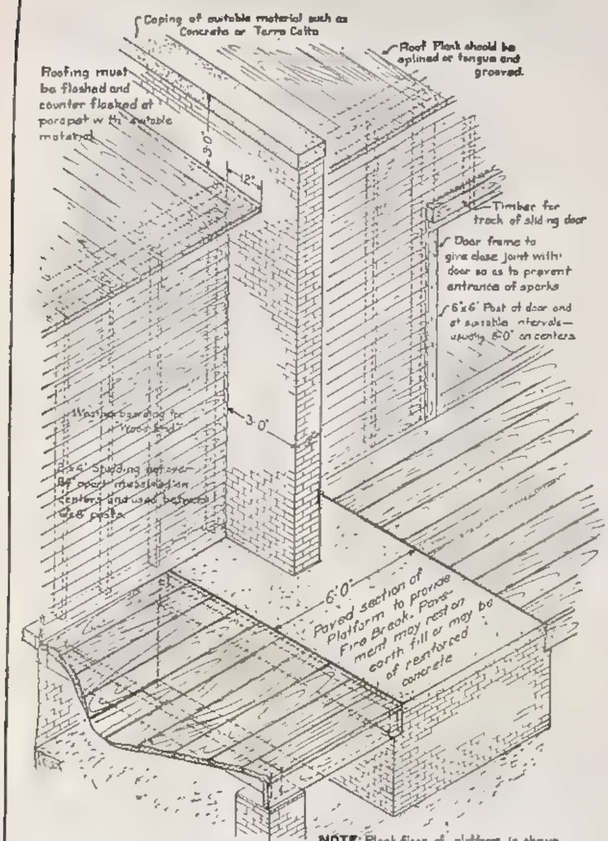
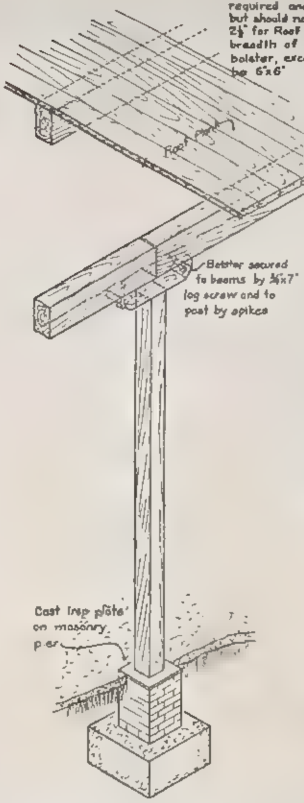

Coping of suitable material such as Concrete or Terra Cotta
Roof Plank should be splined or tongue and grooved.
Roofing must be flashed and counter flashed at parapet with suitable material
3'0"
12"
Timber for track of sliding door
Door frame to give close joint with door so as to prevent entrance of sparks
6"x6" Post at door and at suitable intervals—usually 6'0" on centers
Weatherboarding for Wood End
3'0"
2"x4" Studding [illegible] apart [illegible] centers and used between 6x6 posts
6'0"
Paved section of Platform to provide Fire Break. Pavement may rest on earth fill or may be of reinforced concrete

FIGURE 1.
VIEW OF FIRE WALL EXTENSION WITH DWARF WALL THRU THE WOOD PLATFORM.

NOTE: Plank floor of platform is shown only to illustrate "break". Concrete is best

NOTE: Planking and framing should be proportioned to the loads required and stresses allowed for the material used, but should not in any case fall below the minimum of 2½" for Roof Plank and 3" for Floor Plank thickness; 6" breadth of beam, 8" for least dimension of post and bolster, except that wall posts used as studding may be 6"x6"


Roof Plank
Bolster secured to beams by ¾"x7" log screw and to post by spikes
Cast iron plate on masonry pier

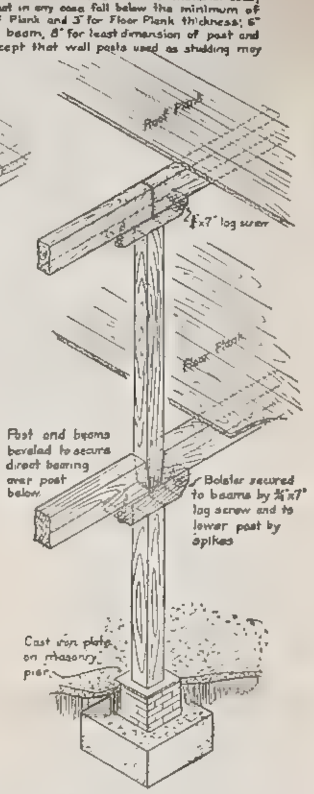

Roof Plank
¾"x7" log screw
Floor Plank
Post and beams beveled to secure direct bearing over post below
Bolster secured to beams by ¾"x7" log screw and to lower post by spikes
Cast iron plate on masonry pier

FIGURE 4.
VIEW OF POST SINGLE STORY.

FIGURE 5.
VIEW OF POSTS MULTI-STORY.

FRAMING, SLOW-BURNING.

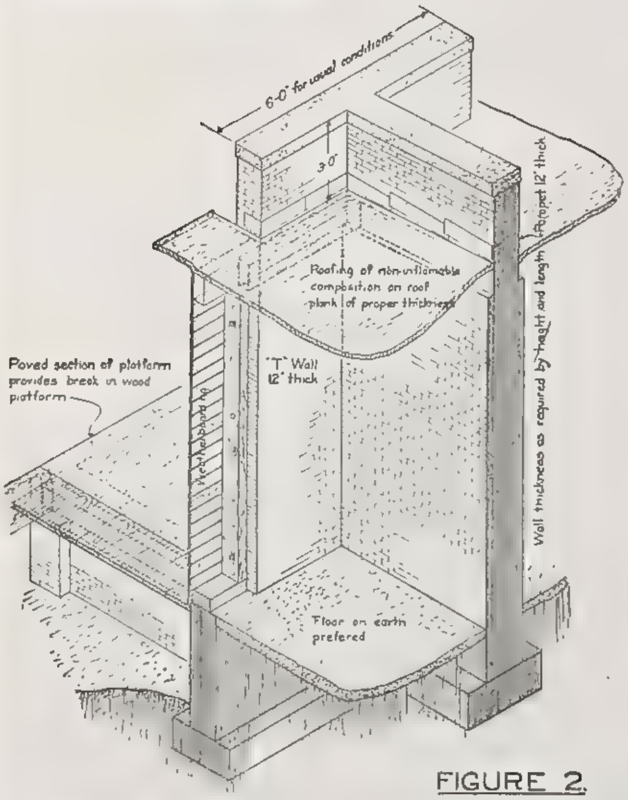

6'0" for usual conditions
3'0"
Parapet 12" thick
Roofing of non-inflammable composition on roof plank of proper thickness
"T" Wall 12" thick
Weatherboarding
Paved section of platform provides break in wood platform
Wall thickness as required by height and length
Floor on earth prefered

FIGURE 2.
VIEW OF FIRE WALL "T" WOOD END WALL, PAVED BREAK IN WOOD PLATFORM, AND DWARF WALLS FOR SEMI-SLOW-BURNING CONSTRUCTION.

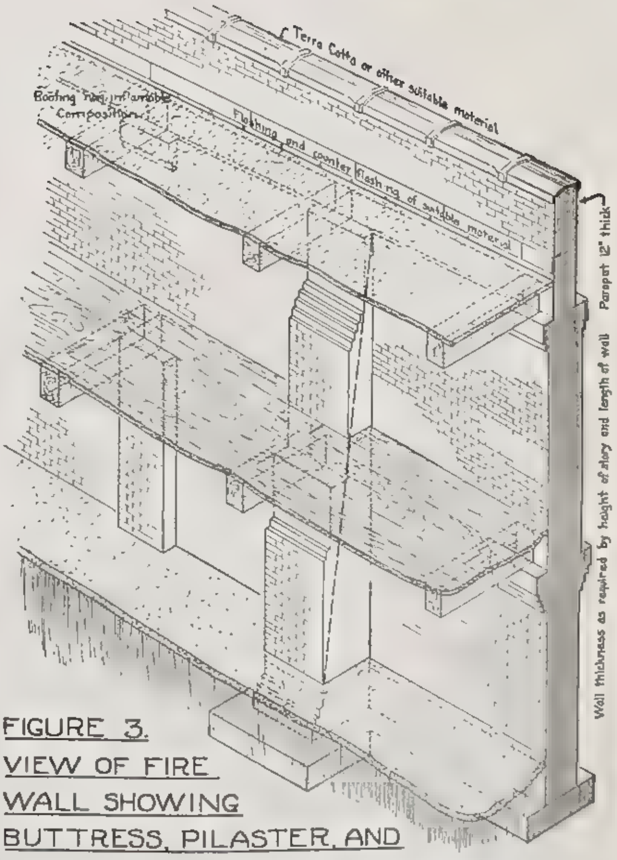
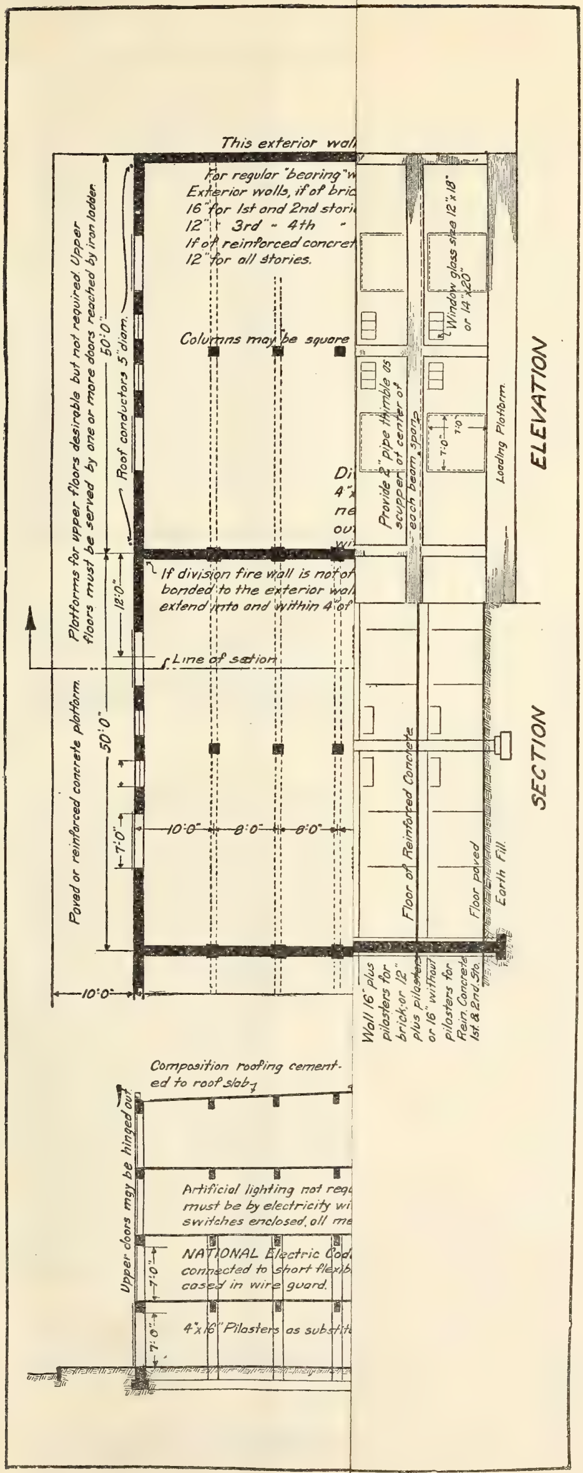
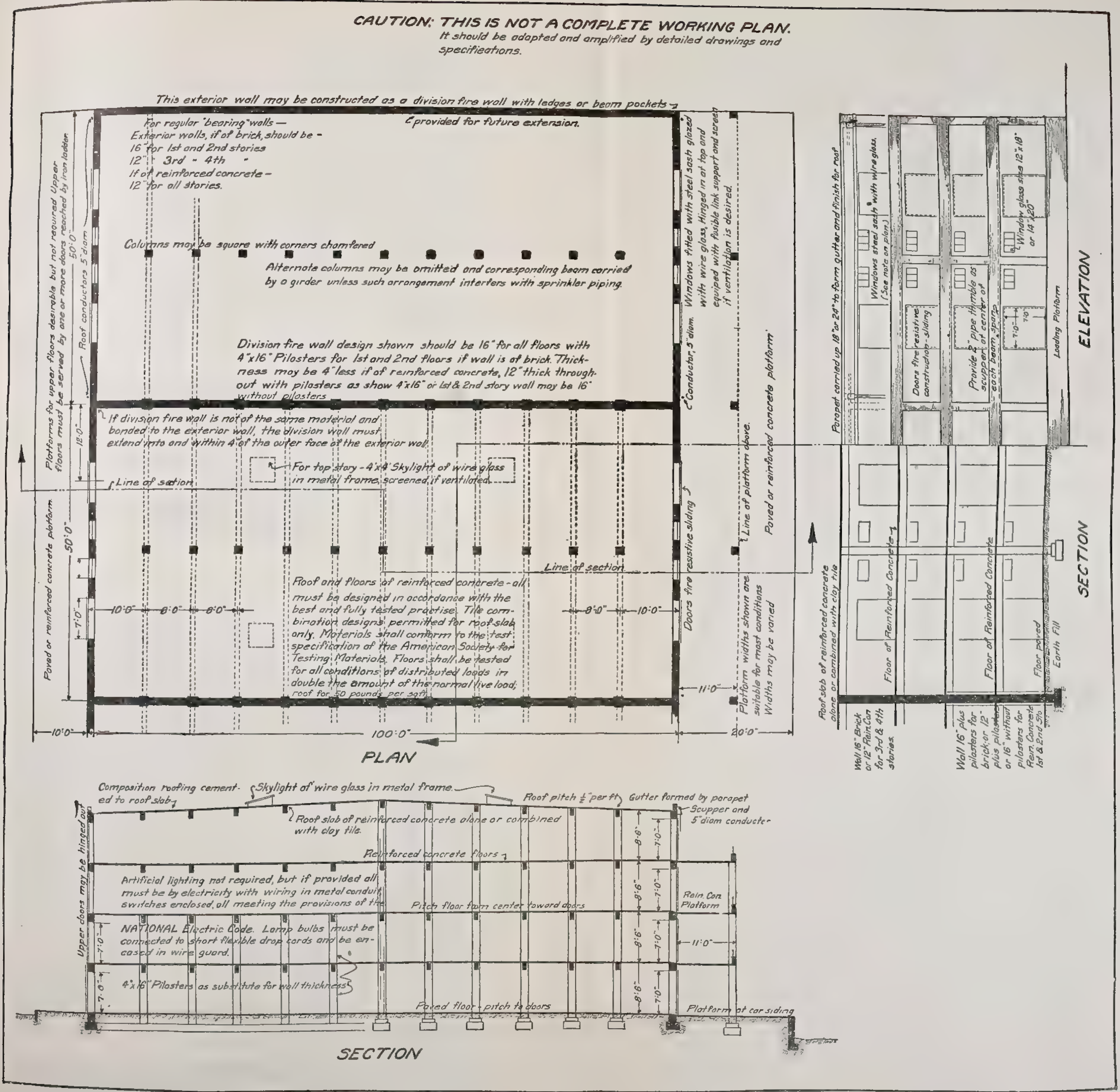

Terra Cotta or other suitable material
Roofing non-inflammable Composition
Flashing and counter flashing of suitable material
Parapet 12" thick
Wall thickness as required by height of story and length of wall

FIGURE 3.
VIEW OF FIRE WALL SHOWING BUTTRESS, PILASTER, AND CORBEL FOR TIMBER SUPPORT.

DETAILS OF FIRE BREAKS FOR SLOW-BURNING CONSTRUCTION.

PLAN F4B.


This exterior wall
For regular "bearing" w
Exterior walls, if of bric
16" for 1st and 2nd stori
12" " 3rd " 4th "
If of reinforced concret
12" for all stories.
Columns may be square
Platforms for upper floors desirable but not required. Upper floors must be served by one or more doors reached by iron ladder.
Roof conductors 5" diam.
50'0"
12'0"
If division fire wall is not of
bonded to the exterior wal
extend into and within 4" of
Line of section
Paved or reinforced concrete platform.
50'0"
7'0"
10'0"
8'0"
8'0"
10'0"
Di
4"
ne
ou
wi
Provide 2" pipe thimble as scupper at center of each beam span.
Window glass size 12"x18" or 14"x20"
7'0"
7'0"
Loading Platform.
ELEVATION
SECTION
Floor of Reinforced Concrete
Floor paved
Earth Fill.
Wall 16" plus pilasters for brick; or 12" plus pilasters or 16" without pilasters for Rein. Concrete 1st & 2nd Sto.
Composition roofing cemented to roof slab
Upper doors may be hinged out.
Artificial lighting not requ
must be by electricity wi
switches enclosed, all me
NATIONAL Electric Cod
connected to short flexib
cased in wire guard.
7'0"
4"x16" Pilasters as substit
7'0"



CAUTION: THIS IS NOT A COMPLETE WORKING PLAN. It should be adapted and amplified by detailed drawings and specifications.

This exterior wall may be constructed as a division fire wall with ledges or beam pockets provided for future extension.

For regular "bearing" walls — Exterior walls, if of brick, should be - 16" for 1st and 2nd stories 12" " 3rd - 4th " If of reinforced concrete - 12" for all stories.

Columns may be square with corners chamfered

Alternate columns may be omitted and corresponding beam carried by a girder unless such arrangement interfers with sprinkler piping.

Division fire wall design shown should be 16" for all floors with 4"x16" Pilosters for 1st and 2nd floors if wall is of brick. Thickness may be 4" less if of reinforced concrete, 12" thick throughout with pilosters as show 4"x16" or 1st & 2nd story wall may be 16" without pilosters

If division fire wall is not of the same material and bonded to the exterior wall, the division wall must extend into and within 4" of the outer face of the exterior wall.

For top story - 4'x4' Skylight of wire glass in metal frame, screened, if ventilated.

Roof and floors of reinforced concrete - all must be designed in accordance with the best and fully tested practise. Tile combination designs permitted for roof slab only. Materials shall conform to the test specification of the American Society for Testing Materials. Floors shall be tested for all conditions of distributed loads in double the amount of the normal live load; roof for 50 pounds per sqft.

Platforms for upper floors desirable but not required Upper floors must be served by one or more doors reached by iron ladder.

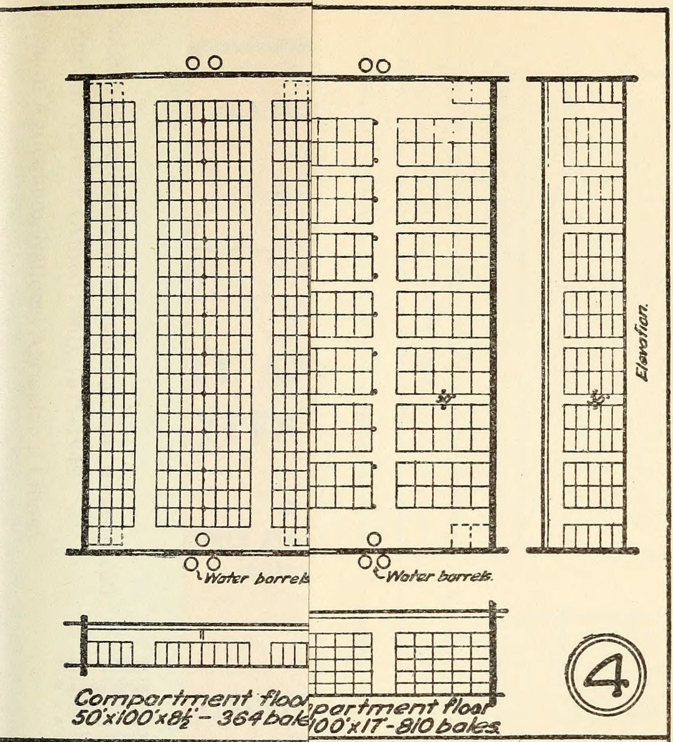
Windows fitted with steel sash glazed with wire glass, hinged in at top and equiped with fusible link support and screen if ventilation is desired.

Platform widths shown are suitable for most conditions Widths may be varied

Artificial lighting not required, but if provided all must be by electricity with wiring in metal conduit, switches enclosed, all meeting the provisions of the NATIONAL Electric Code. Lamp bulbs must be connected to short flexible drop cords and be encased in wire guard.

Roof conductors 5" diam.
50'0"
12'0"
Line of section
50'0"
7'0"
Paved or reinforced concrete platform
10'0" 8'0" 8'0"
8'0" 10'0"
Conductor, 5" diam.
Doors fire resistive sliding
Line of platform above.
Paved or reinforced concrete platform
Line of section
11'0"
10'0"
100'0"
20'0"
PLAN
Composition roofing cemented to roof slab
Skylight of wire glass in metal frame.
Roof pitch ½" per ft.
Gutter formed by parapet
Scupper and 5" diam conductor
Roof slab of reinforced concrete alone or combined with clay tile.
Reinforced concrete floors
Pitch floor from center toward doors
Rein. Con. Platform
11'0"
8'6" 7'0"
8'6" 7'0"
8'6" 7'0"
8'6" 7'0"
Upper doors may be hinged out
7'0"
7'0"
4"x16" Pilosters as substitute for wall thickness
Paved floor - pitch to doors
Platform at car siding
SECTION
Parapet carried up 18" or 24" to form gutter and finish for roof
Windows steel sash with wire glass. (See note on plan)
Doors fire resistive construction - sliding
Provide 2" pipe thimble as scupper at center of each beam span
Window glass size 12"x18" or 14"x20"
7'0"
7'0"
Loading Platform
ELEVATION
Roof slab of reinforced concrete alone or combined with clay tile
Floor of Reinforced Concrete
Floor of Reinforced Concrete
Floor paved
Earth Fill
Wall 16" Brick or 12" Rein.Con. for 3rd & 4th stories
Wall 16" plus pilasters for brick; or 12" plus pilasters or 16" without pilasters for Rein. Concrete 1st & 2nd Sto.
SECTION

FIRE-RESISTIVE WAREHOUSE DESIGN F4B.



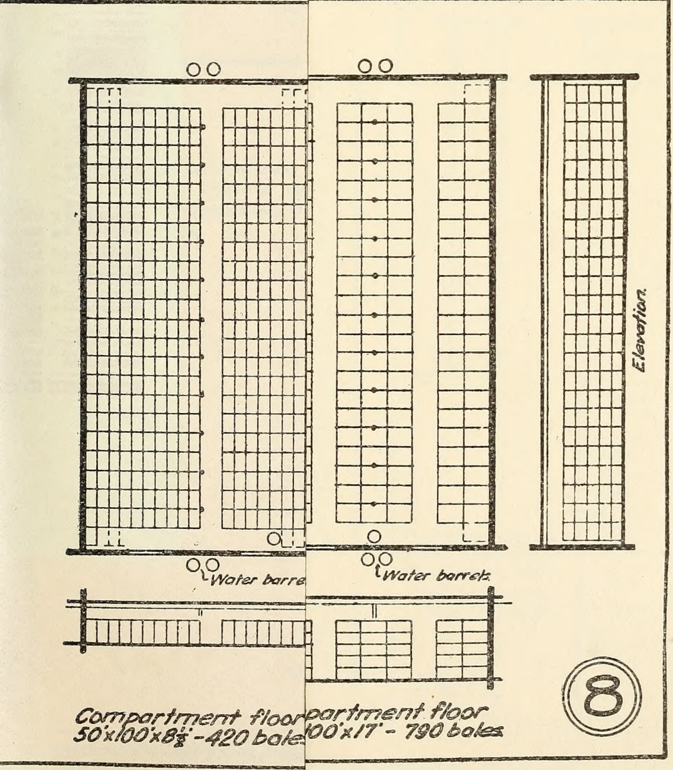
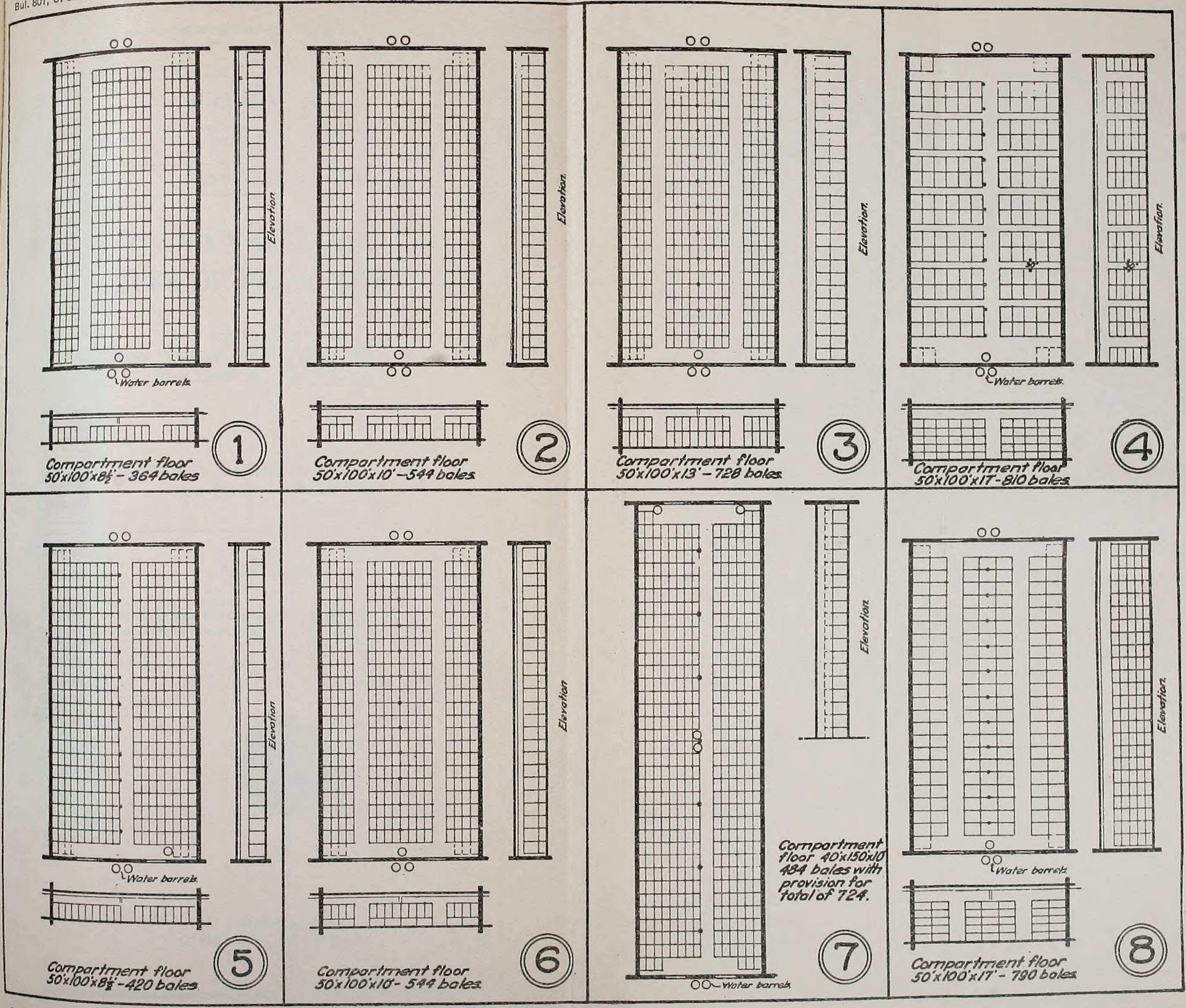


DIAGRAM SHOWING SKETCHES O COMPARTMENTS OF VARIOUS SIZE.



① Compartment floor 50'x100'x8½' - 364 bales

② Compartment floor 50'x100'x10' - 544 bales

③ Compartment floor 50'x100'x13' - 728 bales

④ Compartment floor 50'x100'x17' - 810 bales

⑤ Compartment floor 50'x100'x8½' - 420 bales

⑥ Compartment floor 50'x100'x10' - 544 bales

⑦ Compartment floor 40'x150'x10' 484 bales with provision for total of 724.

⑧ Compartment floor 50'x100'x17' - 790 bales

Diagram Showing Sketches of Various Arrangements for Storing Cotton Showing the Number of Bales Which May be Arranged in Compartments of Various Size.